NOKIA

Broadband Systems

D50 Documentation

Volume 1

General Information

NOKIA

VOLUME 1 GENERAL INFORMATION

Contents

Introduction to D50 Documentation

Introduction D50 documentation provides complete detailed instructions on how to install, test, and commission a D50. This documentation complies with all requirements in Telcordia Technologies Technical Reference documents GR-454 *Generic Requirements for Supplier-Provided Documentation*, and IP-10260 *Standards for Task Oriented Practices (TOPS)*.

Target Audience D50 documentation volumes are written at different levels of detail based on the reader's needs. Below is a list of the various volumes and the intended target audience for each.

Number	Title	Target Audience
Volume 1	General Information	Anyone with a need to understand more about the D50 System and planning requirements.
Volume 2	Installation	Installation and Testing Technicians, and Engineers (Detailed Level Procedures, or DLPs).
Volume 3	Commissioning	Testing Technicians and Engineers (DLPs).
Volume 4	Provisioning	Provisioning Technicians and Engineers (DLPs).
Volume 5	Maintenance and Testing	Maintenance and Testing Technicians and Engineers (DLPs).
Volume 6	Craft Terminal	Testing and Installation Technicians and Engineers (Reference manual for Craft Terminal).

Information Mapping Style All documents are written in Information Mapping style, which presents information in small units or blocks. Each information block is identified by a subject label in the left margin and is separated from the next information block by a horizontal line. Subject labels make it easy for the reader to scan the document and to find information on a specific subject.

Each DLP lists the required equipment and tools to perform the job, and provides step by step instructions (supported by graphics where appropriate) to help the reader perform each task.

SECTION 1 PRODUCT DESCRIPTION

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D50 Solution

The D50 Broadband Access Node is a Digital Subscriber Line Access Multiplexer (DSLAM) for service providers offering advanced data networking services for business and residential customers. The D50 provides digital subscriber line interfaces to connect to thousands of subscribers to a broadband ATM (Asynchronous Transfer Mode) network across existing twisted pair telephone lines. The D50 multiplexer's downstream data rates range up to 8 Mbps and upstream data rates up to 1 Mbps.

The deployed technologies include Discrete Multi-Tone (DMT) modulation ADSL (Asymmetric Digital Subscriber Line), Single pair High speed DSL (SHDSL), Symmetrical Digital Subscriber Line (SDSL), ISDN Digital Subscriber Line (IDSL), DS1, and Asynchronous Transfer Mode (ATM).

The D50 also solves the local switch congestion problem by separating voice-frequency signals from the high-speed data in the Central Office or remote site, and routing data traffic off the voice telephone switch.

System Structure. A D50 system is a two stage ATM multiplexer with a D50 node consisting of:

- A Master Control Shelf (MCS) which performs the second-stage multiplexing and provides the interface to the ATM network. It also performs central power supply, control and network management functions.
- Up to 12 Line Card Shelves (LCSs) which house the first-stage multiplexer and provide mounting slots for the DSL line cards that deliver the data or DSL service to the end users.
- Up to 12 optional, modular Low Pass Filter Shelves (LPFS) are available for ADSL applications when the local loop is used for both voice and data.
- D50 Craft Terminal is used for initial commissioning and element management.
- NetAct for Broadband is used for element management.

System Capacity. One MCS can support up to 12 LCSs. Each LCS can house up to 24 line cards. The D50 scales to 2304 lines per system. Configuration options include co-locating the MCS and LCSs, remotely locating one or more LCSs, or using both configurations. These options provide the operator with a flexible network architecture supporting both low and high penetration rates of xDSL services.

The multi-service line card mounting slots support insertion of any D50 line card, including:

- Octal Rate Adaptive ADSL (DMT8a-4) with data rates delivering up to 8 Mbps downstream and 1 Mbps upstream[1].
- Octal Rate Adaptive ADSL (DMT8a-3) with data rates delivering up to 8 Mbps downstream and 1 Mbps upstream.
- Octal SDSL (SDSL8)—2B1Q interface, includes ATM translation, and multi-rate transmission up to 1.536 Mbps.
- Octal SDSL (SDSL8+) line card supporting 8 ports of symmetric bit-rate transmission using 2B1Q line code. The bit rate is variable and ranges from 144 Kbps to 2.3 Mbps, in 8 Kbps increments. This line card is backward compatible with existing SDSL CPE and includes Autobaud.
- Octal SHDSL (SHDSL8) line card supporting 8 ports of symmetric bit-rate transmission using multi-level Trellis Coded Pulse Amplitude Modulation (TC PAM). The payload rate is variable and has a minimum range of 64 Kbps to over 2.3 Mbps in 64 Kbps increments. The Release 11.0 SHDSL8 line card includes a pair bonding feature which doubles the port bandwidth, providing a maximum of 4.6 Mbps of symmetric service on a combined port pair.
- Quad DS1 line card uses FRF.5 and FRF.8 FR-IWFs (Frame Relay Interworking Functions) to support Frame Relay transmissions, and PPP (Point-to-Point Protocol) to support Ethernet transmissions.
- Octal IDSL (IDSL8) line card supporting 8 ports using 2B1Q line code interface, dedicated 128/144 Kbps.

Network Architecture. The D50 can be deployed in a centralized configuration in a Central Office or in a distributed configuration where the MCS and LCS are located in different locations.
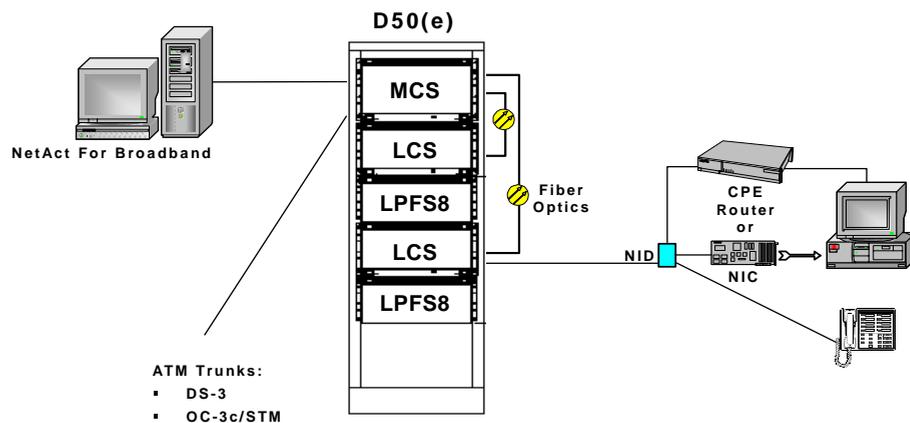
Figure 1-1: D50 System Components

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[1] The DMT8a-4 line card also supports speeds up to 10.8 Mbps in 32 Kbps increments in Interleave Mode based on "S=1/2" from the ITU-T G992.1 standard, when used in conjunction with an "S=1/2"-compliant CPE.

ATM Over DSL Architecture

With ATM over DSL (Digital Subscriber Line) technology, the D50 Broadband Access Node supports high-speed data communication services including fast Internet and intranet access, video and entertainment services, and LAN interconnection.

D50 nodes support the following types of interfaces:

- Tributary or Aggregate ATM.
- Tributary DSL.

The D50 uses ATM technology to statistically multiplex traffic between the subscribers and the network. The ATM is terminated in the end-user CPE (Customer Premises Equipment) or in an ATM end system. Upper layer protocols, like IP, are conveyed transparently in the ATM payload through the D50.

The D50 is a Virtual Path / Virtual Channel (VP/VC) multiplexer. It performs multiplexing of the connections on the VC-level and uses ATM UNI 3.1 cell format. The maximum number of VPs from the MCS towards the ATM network is 256. The maximum number of VCs is 65,536.

ATM QoS – Traffic Management

The D50 supports Permanent Virtual Circuit (PVC) connections, providing always-available configured connections. The current D50 Quality of Service (QoS) implementation supports CBR (Continuous Bit Rate), VBR-rt (Variable Bit Rate real-time), VBR-nrt (Variable Bit Rate non-real-time), UBR (Unspecified Bit Rate), and UBR+ (Unspecified Bit Rate with minimum cell rate guarantee) service classes.

When an OC-3 optical link (155 Mbps) is used, each Master Line Card Adapter (MLA) card has 64K cells buffer capacity, which is equivalent to approximately 3 MB of ATM payload. The Line Card Shelf Multiplexer (LSM) has buffering for 2K cells in the downstream direction per DSL port.

When a DS-3 link (45 Mbps) is used, each LSMT3 card has buffering for 64K cells in the upstream direction. In the downstream direction, the MLAT3 has buffer capacity for 64K cells and the LSM for 2K cells per DSL port.

A DS-1 interface (4xDS-1) is also available for connecting a remote Line Card Shelf or D50 Remote Access Module (RAM) to the D50 MCS. Each LSMT1 card has a 2K cell allocation for its downstream and upstream buffering. The MLAT1 card includes 64K cells of buffer capacity.

Quality of Service—ATM QoS. ATM QoS[2] capabilities are supported in the DS3TQ and OC3TQ[3] trunk cards. ATM QoS provides the following features:

- Multiple classes of service:
  - Constant Bit Rate (CBR) is used by connections that request a static amount of bandwidth to be continuously available during the connection life-time. Examples are real-time video, audio, circuit emulation services, and audio-video distribution such as TV, Pay-per-view, distance learning. CBR services provide connectivity up to a peak cell rate with an upper bound of cell delay variation tolerance. The source may emit cells at, or below the negotiated peak cell rate at any time for any duration and the QoS commitments still pertain.

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[2] ATM QoS is supported in Release 6.0 and above.

[3] OC3TQ is a generic reference to the OC3TQL, OC3TQM, and OC3TQS trunk cards.

- Variable Bit Rate real-time (VBR-rt) service category supports applications requiring variable bandwidth with tight bounds on delay. Cells are generated at arbitrary time intervals and delivered with bounded cell delay variation and cell loss ratio. Examples are variable bit rate CODECs, aggregated voice with silence removal, video conferencing and loop emulation services with AAL2.
  - Variable Bit Rate non-real-time (VBR-nrt) service category supports applications requiring variable bandwidth with less stringent limits on delay as in the case of transaction processing. Cells are generated at arbitrary time intervals and delivered with bounded cell delay variation and cell loss ratio.
  - Unspecified Bit Rate (UBR, UBR+) is intended for applications that do not require a fixed bandwidth or fixed interval of transmission, and are highly tolerant of delay and loss. Examples are file transfer, e-mail, and LANs.

    UBR. With UBR, there is no explicit commitment from the network provider regarding capacity or throughput. No objective is specified for the QoS parameters and the only traffic parameter is PCR (Peak Cell Rate).

    UBR+. UBR+ allows operators to provide a UBR service that is better than best effort. UBR+ guarantees a minimum cell throughput, has EPD/PPD congestion control support, and allows the connection to burst to the Peak Cell Rate. The traffic parameters used for UBR+ are PCR and MCR (Minimum Cell Rate).

- Traffic shaping.
- Traffic policing[4].
- LSMT1 and LSMT3 QoS medium priority queue downstream traffic management:
  - Early Packet Discard (EPD) and Partial Packet Discard (PPD) congestion control support mechanisms for AAL5 VBR-nrt and UBR+ connections.
  - Minimum guaranteed service (starvation cycle).
  - Fixed allocation of a 1000 cell buffer per line port.
- Congestion control and avoidance, including Early Packet Discard (EPD), Partial Packet Discard (PPD), and Explicit Forward Congestion Indication (EFCI)[5].
- Connection Admission and Control (CAC).
- Performance Monitoring.
- Provisionable buffering and queue depths (in cells) for each priority queue.
- Operations And Maintenance (OAM).

  Note: OAM (F4 and F5) fault management functions such as standard loopback (segment), plus AIS and RDI alarms are supported on the DS3TQ and OC3TQ trunk cards.

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[4] Upstream direction only.

[5] EPD, PPD, and EFCI settings are not applicable for LSM upstream queues for an OC-3 MLA/LSM-series interface (MCS to LCS connection). Additionally, LSM downstream queues for EPD, PPD and EFCI are set to "low" (default) for an OC-3 MLA/LSM interface.

ATM Quality of Service — Priority Queuing. The D50 supports Quality of Service (priority queuing) for optimizing the use of network resources. QoS functions allow users to provision bandwidth allocation to three priority level queues. For example, 90% of the bandwidth can be allocated for high-priority traffic, and 10% can be guaranteed to the lower priority queues to prevent "starvation." All queues can be monitored at a given congestion point simultaneously, and can be independently modified.

In D50 releases prior to Release 10, priority queuing was scheduled first by port, then by priority. ATM QoS is now scheduled first by priority, then by port, so that high priority traffic is serviced first. In addition, EPD and PPD have been added for the medium priority queue (VBR-rt and VBR-nrt traffic); they were previously supported only on the high and low priority queues.

Several features exist to ensure the fairness and scheduling of traffic from the LSM to the line cards (egress traffic), including starvation control on the medium priority queue in the ingress direction to the LSM from the line cards:

- Egress scheduling of ATM QoS; first by priority, then by port.
- Starvation control for ingress medium priority traffic (not available on the LSM2).
- Starvation control for egress low priority traffic.
- Starvation control for egress medium priority traffic.
- EPD/PPD discarding for egress medium priority traffic.

A 1K cell buffer per port is provisioned in the LSM, creating dedicated buffer resources for the line cards.

QoS priority queuing functions take place in the MCS through the MLA cards in both the upstream and downstream direction, and in the LCS through the LSM cards (downstream direction). Primary features include:

- Support for three levels of priority queuing: High, Medium and Low.
- Congestion monitoring and management, including:
  - Early Packet Discard (EPD). Once the queue EPD congestion threshold is reached, EPD prevents all new packet streams from entering the queue while the existing stream is processed.
  - Partial Packet Discard (PPD). Once the queue PPD congestion threshold is reached, PPD discards all the remaining cells of the packet that has already entered the queue, until the End Of Cell (EOC) marked cell is detected.
  - Explicit Forward Congestion Indication (EFCI). Notifies other network resources that a given queue is in a congestion state.
- Provisionable EPD and PPD thresholds.
- Provisionable queue depths (in cells) for each priority queue

Table 1-1: QoS Hardware and Software Compatibilities

	QoSV4 Priority Queuing		ATM QoS[1]	
	Hardware	**Software**	**Hardware**	**Software**
D50 Trunk Cards	DS3T2, OC3T2, OC3T2M, OC3T2L	Release 5.1	DS3TQ, OC3TQL, OC3TQM, OC3TQS	Release 6.0, 8.0, 9.0, 9.1, 10.0, and 11.0
ATM-based MLA Cards	MLA2, MLA2S, MLA2L, MLAT3, MLAT1	Release 5.1	MLA2, MLA2S, MLA2L, MLAT3, MLAT1	Release 6.0, 8.0, 9.0, 9.1, 10.0, and 11.0

[1] ATM QoS supports CBR, VBR-nrt, VBR-rt, UBR, and UBR+.

Voice Over DSL (VoDSL)

The Nokia D50 platform supports the deployment of VoDSL in an operator's network through the effective guarantee of voice quality by minimizing delay and latency through the use of ATM QoS mechanisms available on the platform.

The Nokia D50 can interoperate with a wide range of VoDSL Integrated Access Devices (IAD) and VoDSL Gateways.

The same D50 platform used to offer other DSL services can also be used to offer voice services with the use of an Integrated Access Device at the customer premises, and a GR303 Voice Gateway at the Central Office, as shown in Figure 1-2.
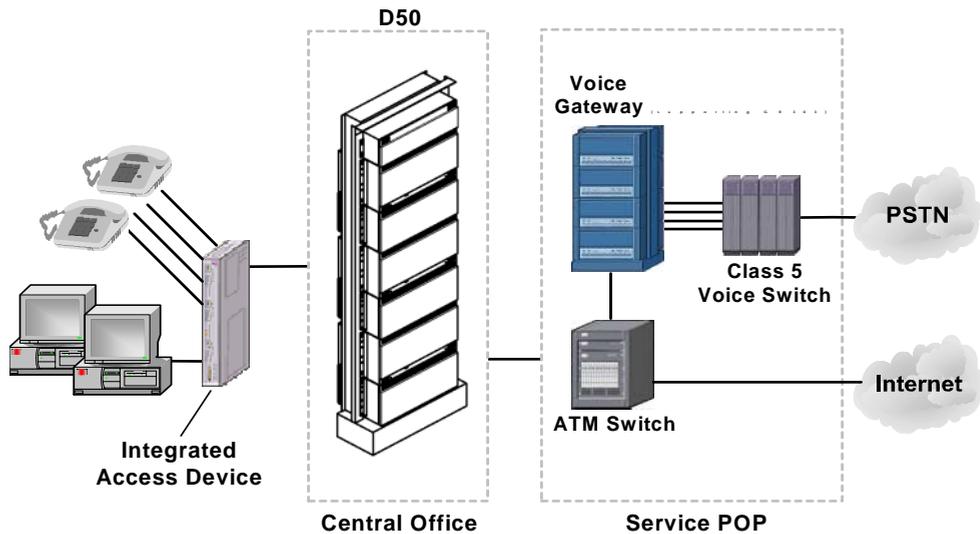
Figure 1-2: D50 VoDSL Implementation

Integrated Access Device (IAD). An IAD resides at each subscriber premises and uses ATM and DSL technologies to multiplex all of the subscriber's voice and data traffic onto a single copper pair. The IAD provides a subscriber with standard local telephone service via up to 24 analog POTS ports and Internet/Data service via a standard Ethernet connection. The telephone lines can be connected to the subscriber's existing telephone equipment including analog telephones, key systems, fax machines, and dial-up modems.

ATM over DS1. A customer premises IAD with a TDM-based (T1) interface can be interfaced with the ATM network through the D50 DSLAM through the ITU-T G.804 protocol. This allows operators to provide an end-to-end service on a ATM network supporting IP and telephony traffic from discrete analog interfaces such as a PBX trunk or a telephone. The analog to digital conversion occurs at the external CPE or IAD and is mapped to ATM VC connections at the DS1 line card.

DSLAM (D50). The key component is the D50 DSL access multiplexer (DSLAM) co-located in the Central Office. The D50 multiplexer receives voice and data traffic from each subscriber and uses ATM technology to multiplex it onto a single back-haul facility for transport back to the service Point of Presence (POP). In addition, the D50 supports the necessary Quality of Service to ensure that voice traffic is met with minimum delay and is prioritized over other non-delay sensitive traffic such as Internet traffic.

Voice Gateway. The Voice Gateway is a large scale platform that receives local voice traffic from all subscribers in ATM format and efficiently integrates it back into the existing Class 5 voice switch.

Efficient Use of Transmission Capacity

The D50 supports Rate Adaptive Asymmetrical Digital Subscriber Line (RADSL) which provides data rates of up to 8 Mbps downstream and 1 Mbps upstream, and enables simultaneous use of traditional telephone service (POTS) over the same line.

The asymmetrical data transfer rate is ideal for applications in which the information flow from the network towards the end user is considerably greater than in the opposite direction (for example, Internet access or providing entertainment services to residential users).
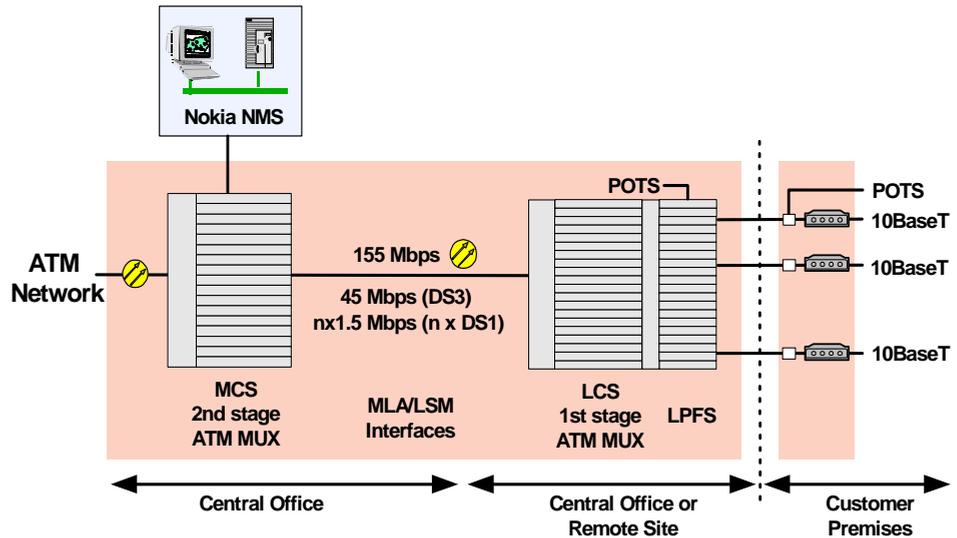
Figure 1-3: Schematic Diagram of a D50 System

Low-Pass Filter Function. An optional, modular Low Pass Filter Shelf (LPFS) is available for ADSL applications when the local loop is used for both voice and data. A splitter function separates the low frequency voice signal from the high frequency ADSL data signal.
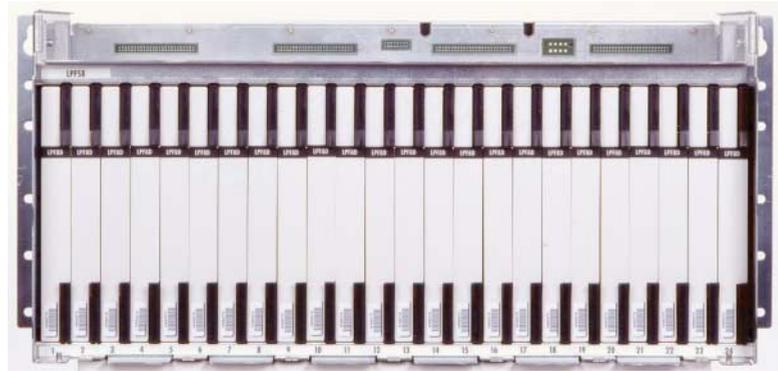
Figure 1-4: Low Pass Filter Shelf

ADSL line circuits have high-pass filters that block the voice frequency signals. The LPFS is connected between the LCS and the voice switch. The voice signal is "split off" at the LPFS and sent to the Class 5 switch unimpeded through the filter/splitter circuit, while the ADSL line card signals pass through to the ADSL line card.

A twisted pair carries the POTS and data signals from the Central Office Main Distribution Frame (MDF) to the LPFS. The LPFS may mount below or above the Line Card shelf, in an adjacent frame, or remotely from the multiplexer (within 655 cable feet). The LPFS contains low pass filter plug-in cards with eight low pass filter circuits. Each passive low pass filter circuit separates the voice frequency POTS signals from the ADSL signal with no impairment to either service.

IDSL8, DS1, SDSL8, SDSL8+, and SHDSL line cards use the entire frequency spectrum for data transmission and do not support POTS services requiring the low pass filter function. For these line cards, the network service provider connects cables from the MDF directly to the Line Card Shelf.

Scalable Broadband Access	The Nokia D50 offers a scalable solution for operators who wish to provide end users simultaneous access to the broadband network and traditional telephone service.

The modular structure of the D50 node facilitates easy upgrading from smaller installations to a large scale installation; by adding the maximum of 12 Line Card Shelves (LCSs) to the Master Control Shelf (MCS), up to 2304 subscribers can be connected to a single D50. The D50 can be located either at one Central Office site or the LCS component of the D50 can be distributed to remote sites.

The D50 MCS to LCS link capacities are also scalable. An 4xDS-1 link can be used for a small number of users. As the number of users grows, the 4xDS-1 link can be replaced with a DS-3 or OC-3 (SONET) interface. This allows efficient and cost effective use of transmission systems, which is especially important if the link is leased from another service provider. |
| **Additional Features** | **1:1 Unit Protection.** For added reliability, the vital units of the node—the Master Control Processor (MCP) and the ATM Trunk Interface Card—may be duplicated.

Fault Diagnostics. In addition to the advanced fault and performance management features provided by the network and node management applications, the following may be used in troubleshooting:
- Fan Trays included in each shelf provide alarm indications that are monitored by the system and can be made available to operators via a management system. Alternatively, the Fan Tray alarms can be displayed directly through the Common Systems Interface Panel (CSIP) included in each Master Control Shelf.
- Each D50 card has LED indicators to display the status of the individual card (depending on the card, "FAIL," "ENABL," "ACT," "SYNC," and "ALM" indicators are available). |

**Network
Applications**

The D50 provides fast data connections over existing copper lines simultaneously with traditional POTS traffic.

Figure 1-5 shows how the D50 can be applied to provide LAN (Local Area Network) interconnection services for remote offices. The DSL connection allows the subscribers in a remote office to access the corporate LAN over an ATM network.
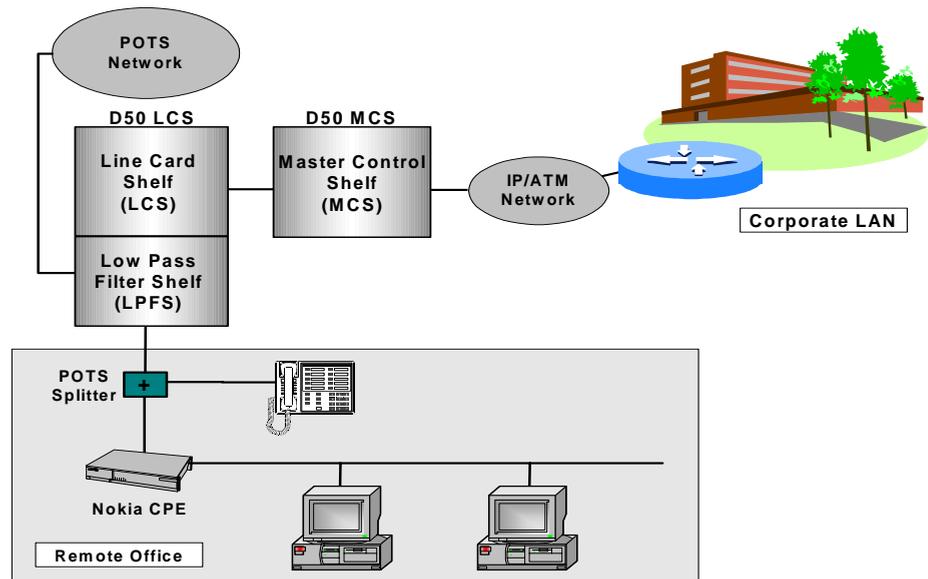
Figure 1-5: D50 for LAN Interconnection for Business Use

Figure 1-6 illustrates how fast Internet access can be provided to SOHO (Small Office/Home Office) or residential users using the D50. The two-stage multiplexing structure is especially beneficial in the introduction phase when the DSL subscribers are geographically scattered and subscriber penetration is relatively low. The D50 brings the first multiplexing stage close to the customers and provides effective concentration of traffic in both multiplexing stages.
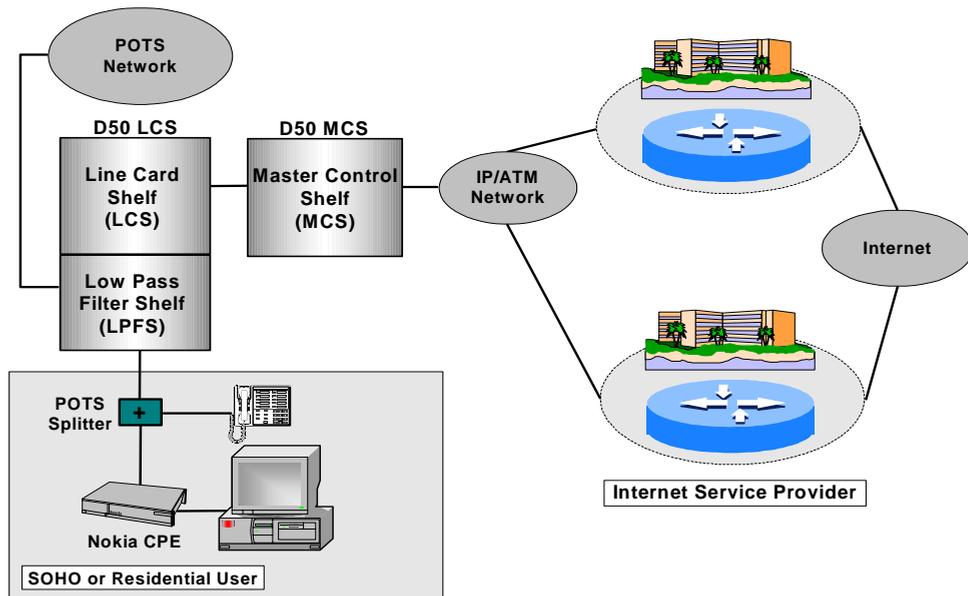
Figure 1-6: D50 for Fast Internet Access for SOHO or Residential Use

Figure 1-7 shows an example of applying the D50 for providing access to the corporate LAN or the Internet for SOHO users. The connection to the corporate LAN can be directly from an Internet Service Provider (ISP) or via the Internet.
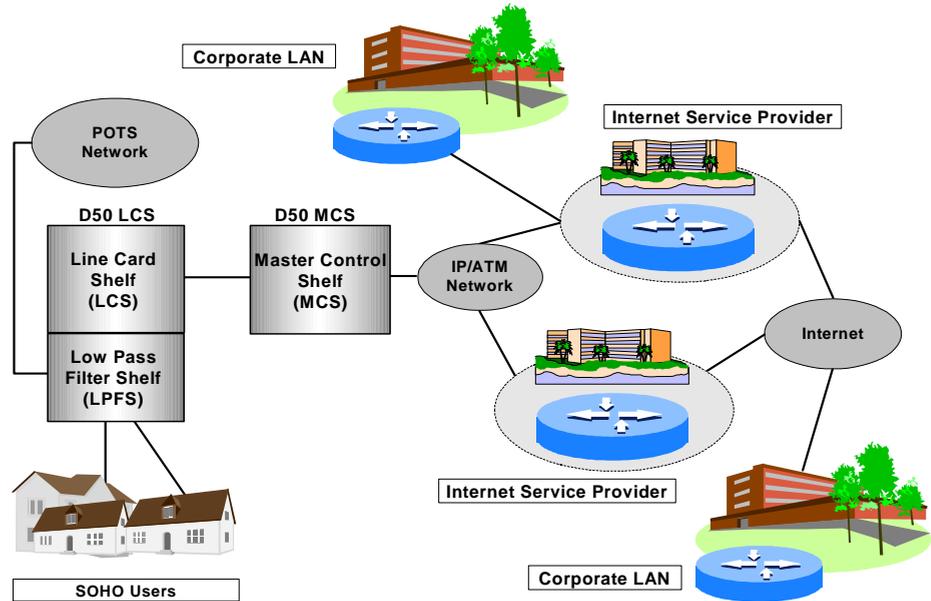
Figure 1-7: D50 for Corporate LAN and Internet Access for SOHO Use

Figure 1-8 shows an example of providing a T1 ATM-based leased line replacement service for Frame Relay services that are currently using TDM based access systems. The DS1 line card provides the FR-IWF (FRF.5 and FRF.8) interworking to ATM necessary to support such a service.

In comparison to other xDSL technologies, Central Offices using D50s with DS1 line cards can provide extensive reach because service can be repeated or transmitted through an existing transmission infrastructure. Additionally, T1 can be supported on existing line terminal (span) systems. Repeated T1 lines provide further reach and service accessibility in the network.
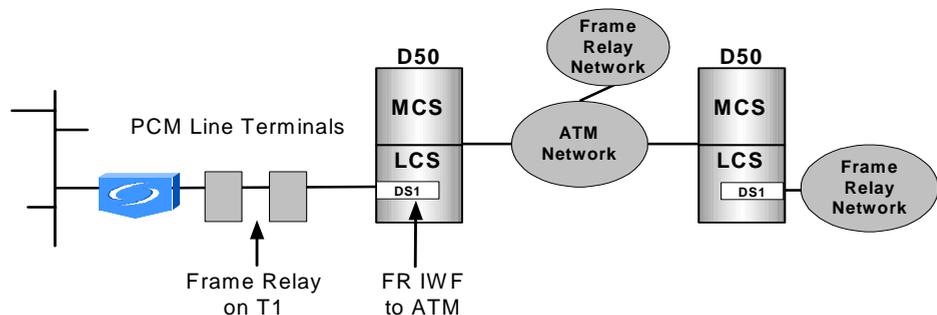
Figure 1-8: D50 T1 ATM-Based Leased Line Replacement Service

**Site
Applications**

D50 nodes can be used in a centralized configuration where the complete system is installed in a Central Office, or in a distributed configuration where the Master Control Shelf and the Line Card Shelves are located at different sites.

In addition, depending on the node configuration, there are several service options:

- Data plus Voice service.
- Data Only service.
- Combination of Data plus Voice and Data Only service.
- Remote LCS with Data plus Voice service.
- Remote LCS with Data Only service.

**Central Office
Configuration**

In a Central Office configuration, the node is installed in adjacent standard 23-inch Telco racks. The MCS to LCS interfaces use single-mode (or multimode) fiber interconnects.
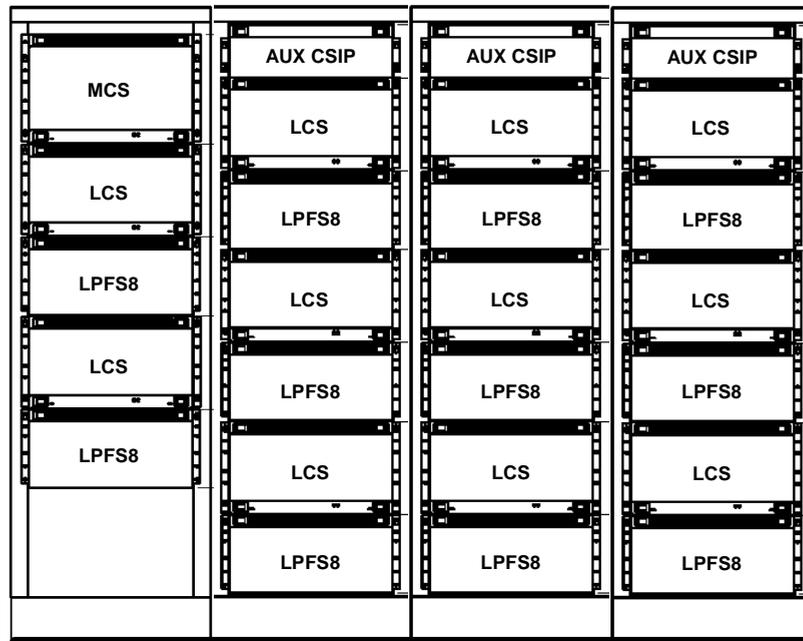
Figure 1-9: D50 Shelves in Standard 23-Inch Telco Racks

Distributed Configuration   Line Card Shelves (LCSS) and D50 RAMs can be located in remote locations such as building equipment rooms, Controlled Environmental Vaults (CEVs), outdoor cabinets, remote Central Offices, and multiple-dwelling unit (MDU) environments. The remote configuration enables service providers to extend DSL services to customers such as corporate campuses, hotels, and MDUs, as well as end users served over "derived" pairs through Digital Loop Carrier systems.

A remote LCS and D50 RAM connects to the D50 using an LSM/MLA-series interface to the MCS. The LSM can be the LSM2 (OC-3 inter-office intermediate reach interface), the LSM2L (OC-3 inter-office long-haul interface), the LSMT3 (DS-3 interface) or the LSMT1 (4xDS-1 Inverse Multiplexed).

Figures 1-10 and 1-11 illustrates a D50 distributed configuration.
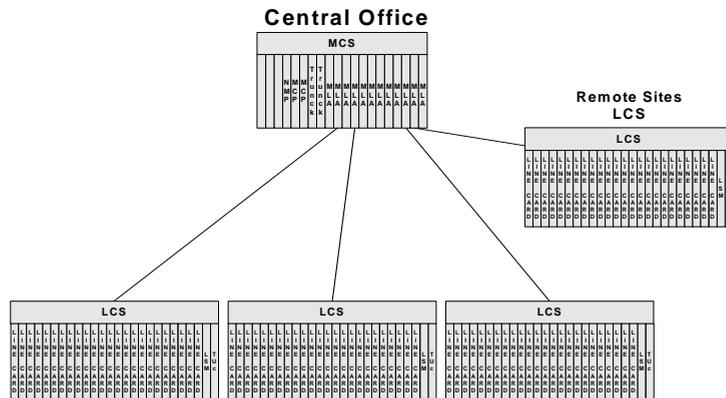
Figure 1-10: D50 in a Distributed Configuration
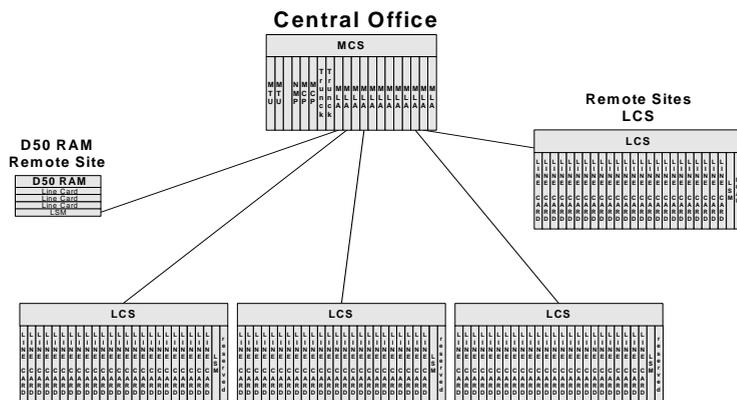
Figure 1-11: D50 in a Distributed Configuration

Data plus Voice Service   If data plus voice service is offered, the Low Pass Filter Shelf (LPFS) must be installed between the Main Distribution Frame (MDF) and the LCS. The LPFS can be co-located with the LCS, co-located with the MDF, or it can be located independently of the MDF and LCS.

Figure 1-12 shows an example of a configuration providing data plus voice service with the LPFS co-located with the LCS.
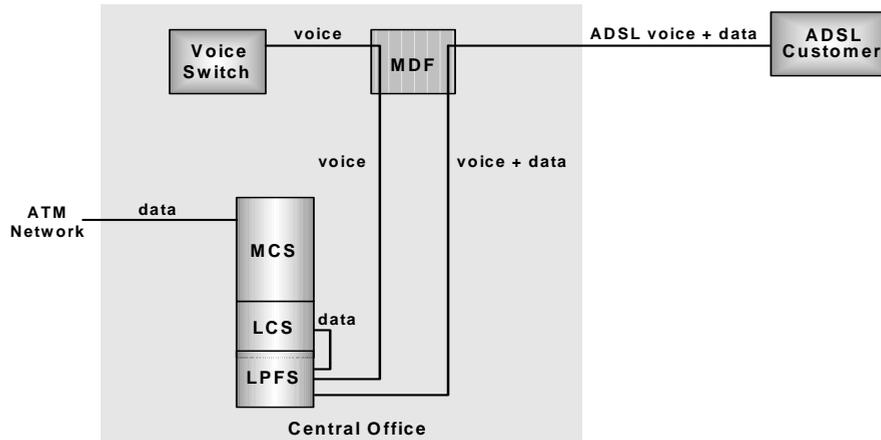
Figure 1-12: D50 Data Plus Voice Configuration

Data Only Service   Some telecommunications service providers may decide not to offer data plus voice service. In this case the LPFS is not needed because no voice signal is carried over the local loop. In this configuration, the D50 would consist of an MCS and one or more LCSs.

Combination of Data plus Voice and Data Only Service   D50 nodes can be configured with some LCSs supporting data plus voice connections, and others supporting data only connections. Such systems would have LPFSs for the LCSs supporting data plus voice, but not for the LCSs supporting data only connections.

Remote LCS   An LCS may be installed at a remote location. This configuration can support both data
plus voice and data only.
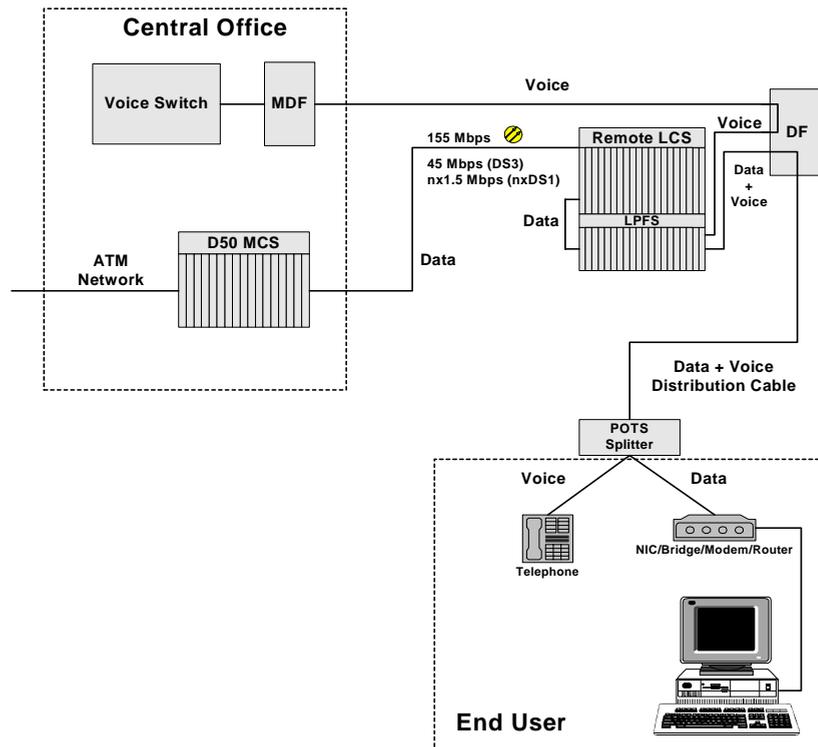
Figure 1-13: Remote LCS Configuration with Data Plus Voice

As shown in Figure 1-14, the data only configuration does not require a connection to the voice switch.
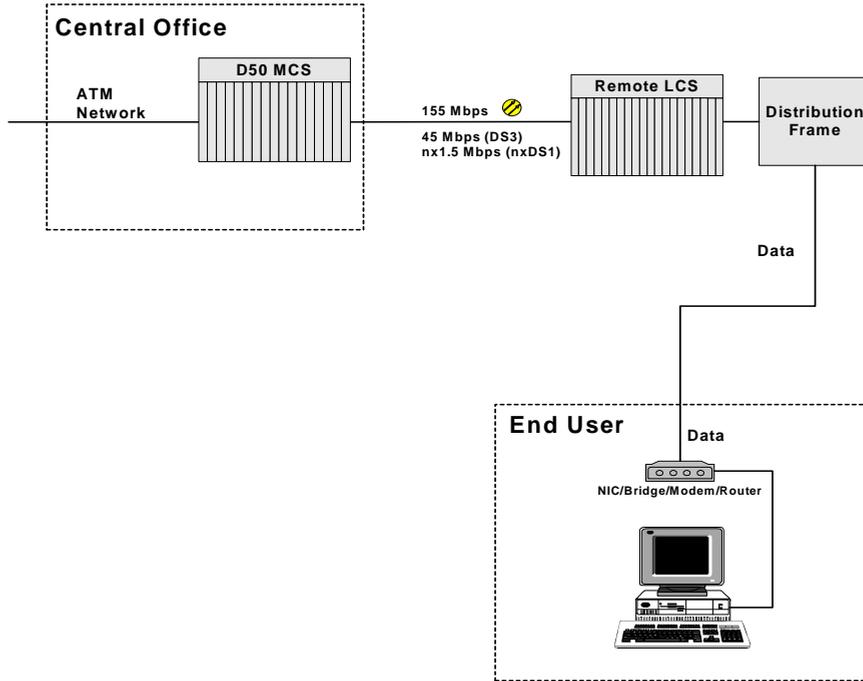
Figure 1-14: Remote LCS with Data Only

Nokia NetAct for Broadband	Nokia NetAct for Broadband is a client/server based system that incorporates a full range of functions for fault, performance, configuration, topology, and security management for the whole Nokia broadband solution, including the D50. NetAct for Broadband offers centralized, high-capacity management capability to minimize the cost associated with operating a large broadband access network.

For more information, refer to the Nokia NetAct for Broadband product description and user documentation.

**D50 Craft
Terminal**

D50 Craft Terminal is a standalone, object-oriented, craft interface configuration and management application. It is designed to communicate directly with a D50 through the serial port using Point-to-Point Protocol (PPP) at speeds up to 38400 baud or via a 10BaseT Ethernet connection, or through an inband network connection through the trunk facility. Craft Terminal operates on a laptop or PC running either the Windows NT or Windows 2000 operating system. This application is ideal for the set-up and installation of D50 systems, initiating communication with D50 element management software, or for quick, on-site diagnosis of hardware-related or local network problems.

Remote Craft Access. Remote Craft Access (RCA) enables the craft technician to connect a PC laptop to the connection panel of a D50 Remote Access Module (RAM) or a remote LCS using the Remote Craft Access Unit (RCAU) card. A communication channel is set up between the access interface and the D50's NMP (Network Management Processor) card that provides remote access to management functions.

A Remote Craft Access Unit is available for the D50 remote line card shelf to provide a direct connection for a PC laptop running Craft Terminal. The RCAU card installs in slot 26 of the remote LCS. In addition to providing an interface for the craft application, this card also allows the LCS to detect external alarms, such as power, door and environmental alarms, and report them directly back to the Central Office via the MCS. The alarms are viewable via a management system. This option eliminates the need for hardwiring of alarms between the adjunct and telephony cabinets, when the LCS is deployed in an outdoor (remote) cabinet application.

D50 System Architecture

A D50 Broadband Access Node consists of a Master Control Shelf (MCS) and up to 12 Line Card Shelves (LCSs) and/or D50 Remote Access Modules (RAMs).
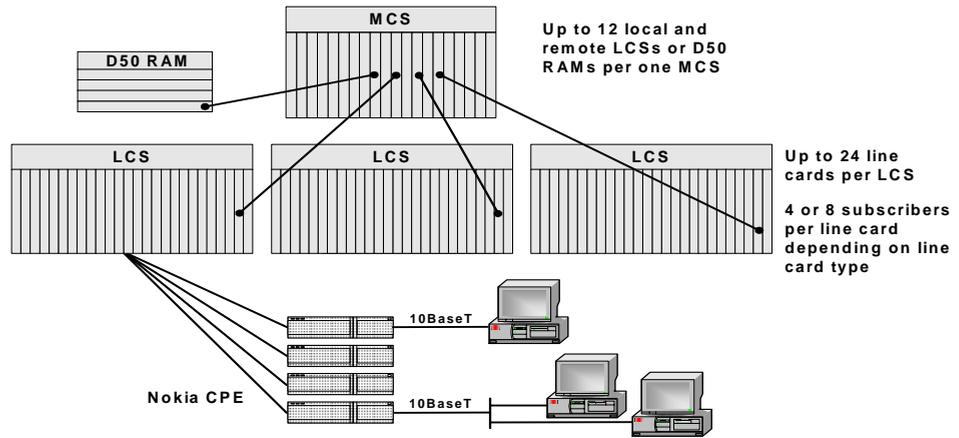
Figure 1-15: D50 Node Architecture
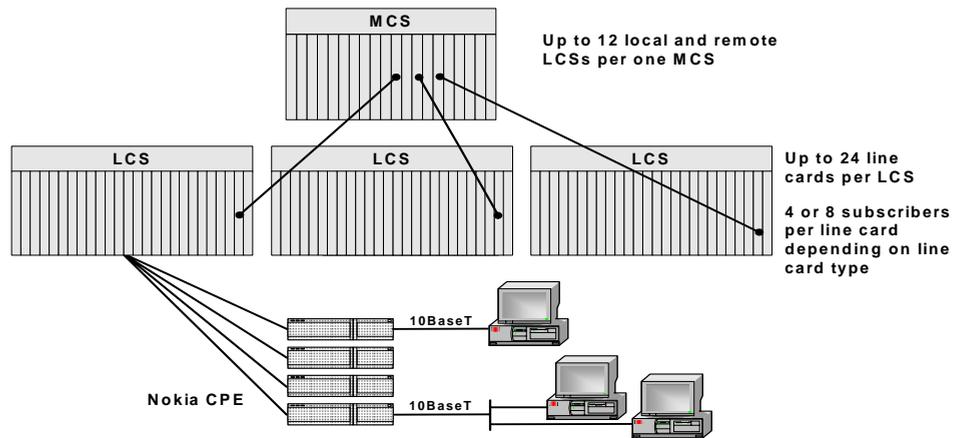
Figure 1-16: D50 Node Architecture

Master Control Shelf (MCS)

Figure 1-17 illustrates a fully loaded Master Control Shelf (MCS):
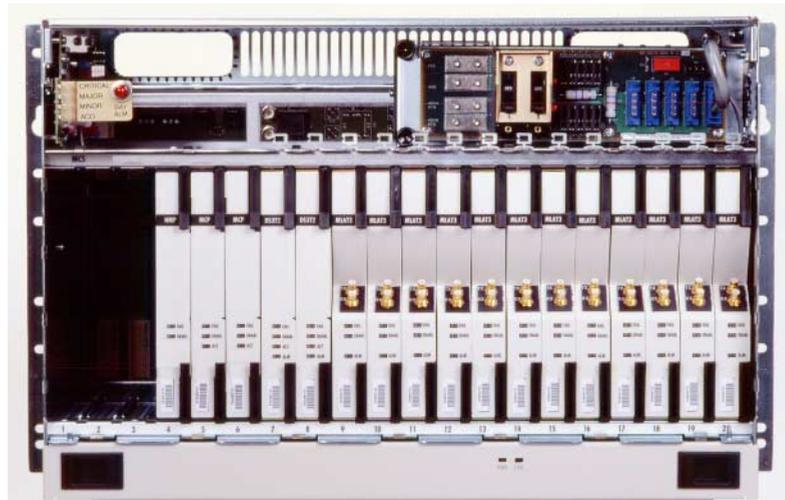
Figure 1-17: D50 Master Control Shelf (MCS)

The Master Control Shelf has 20 unit slots and supports the following system units:

Common Systems Interface Panel (CSIP). The CSIP provides interfaces to Central Office DC power, local alarm contacts, and network management and operations, and supports local Ethernet 10BaseT and RS-232 connections. The CSIP has LEDs to display the current alarm status of the node. The CSIP also distributes power to a maximum of four Line Card Shelves. An Auxiliary CSIP is required for each additional four Line Card Shelves.

Master Timing Unit (MTU). The Master Timing Unit card provides network synchronization for the D50. The MTU card receives a 1.544 Mbps/MHz DS1 signal from a synchronous Network Element that can be traced to a Stratum clock within the timing hierarchy. The DS1 signal can support either ESF (Extended Super Frame) or SF (Super Frame) formats. The MTU card converts the 1.544 Mbps DS1 input signal and outputs a frame-aligned 8 kHz reference signal to the D50 trunk cards. There can be two MTU cards installed in the D50 MCS to provide a redundant path that allows for two separate references (one primary and one secondary) to ensure the transmissions of the D50 have the same average frequency as the digital network.

Craft Terminal displays an alarm in the active alarm dialog box if the MTU card fails or loses its external timing input.

> **Note:** If you are using the MTU card with either a DS3TQ or an OC3TQ trunk card, and you are using two of these trunk cards (primary and standby), the timing option must be set to **External** on both the primary and standby trunk cards.

Network Management Processor card (NMP). The Network Management Processor card controls the node's network management interfaces. The NMP provides all of the protocol support so the D50 nodes can communicate with a management system and Craft Terminal.

Master Control Processor card (MCP). The Master Control Processor card controls the D50 node. The MCP can be duplicated for 1:1 unit protection. The non-volatile

memory of the MCP retains vital provisioning database information and program information in the event the MCS loses power. This allows the node to automatically return to its pre-power failure state when power is restored.

The Master Control Shelf can optionally house two MCPs for reliability reasons. In the event of an active MCP failure, the system will switch to the alternate MCP within 50 milliseconds. The MCP card change-over is not service affecting, and switching from one card to the other does not incur any traffic loss.

ATM trunk card (duplicated for reliability) interfaces between the ATM backbone facility and the multiplexer. The D50 supports two different trunk cards, each with multiple variations:

- DS-3 trunk cards:
  - DS3T – A standard DS-3 format signal with ATM payload.
  - DS3T2 – The DS3T card with priority queuing Quality of Service (QoSV4) capabilities.
  - DS3TQ – The DS3T card with ATM QoS (CBR, VBR-nt, VBR-nrt, UBR, and UBR+) capabilities.
- OC-3 trunk cards:
  - OC3T[6] – A standard SONET OC-3c signal with ATM payload.
  - OC3T2[6] – OC3T card with priority queuing Quality of Service (QoSV4) capabilities.
  - OC3T2L[7] – Single-mode fiber/long haul OC3T card with priority queuing Quality of Service (QoSV4) capabilities.
  - OC3T2M[8] – Multi-mode fiber OC3T card with priority queuing Quality of Service (QoSV4) capabilities.
  - OC3TQS[6] – Short haul OC3T card with ATM QoS (CBR, VBR-nt, VBR-nrt, UBR, and UBR+) capabilities.
  - OC3TQL[7] – Long haul OC3T card with ATM QoS (CBR, VBR-nt, VBR-nrt, UBR, and UBR+) capabilities.
  - O3TQM[8] – Multi-mode fiber OC3T card with ATM QoS (CBR, VBR-nt, VBR-nrt, UBR, and UBR+) capabilities.

Each trunk card multiplexes and demultiplexes up to 12 broadband ATM cell streams from the Line Card Shelves into a standard payload. The "hot-swappable" trunk cards are 1 + 1 protected and can be inserted and removed without disrupting system operation, simplifying network upgrades.

For the DS-3 interface, there are provisions for two trunk cards (one active, the other standby). A relay in the MCS backplane switches the DS-3 facility to the optional standby DS3 trunk card within 50 milliseconds in the event that the active DS3 card fails, providing unit protection.

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[6] The OC3T, OC3T2, and OC3TQS trunk cards have an inter-office intermediate reach (short-haul) optical interface with a target distance of 50 Kft.

[7] The OC3T2L and OC3TQL trunk cards have a target distance of 130 Kft.

[8] The OC3T2M and OC3TQM trunk cards have a target distance of 5 kft.

For the OC-3 interface, there are provisions for two trunk cards (one active, the other standby). This allows the D50 multiplexer to provide both *unit* protection switching (an active card and an optional standby card), and SONET *facility* 1+1 protection switching (two fiber optic cables, one active and one standby).

The D50 supports the following **Master Line Card Adapters (MLA)**:

Note: ATM Quality of Service priority queuing functionality is supported in the following MLA cards:

■ MLA2 – connects to the LSM2 card in the Line Card Shelf through a SONET OC-3c interface at OC-3 rates over multi-mode optical fiber[9].

■ MLA2S – connects to the LSM2S in the Line Card Shelf over single-mode intermediate reach optical fiber[10]. A broadband UNI tributary version, the **OC3L card**[10], supports provisionable VPI/VCI mappings to the trunk or aggregate link, allowing ATM cell streams to be aggregated from standards based ATM network equipment.

■ MLA2L – connects to the LSM2L in the Line Card Shelf over single-mode long-haul optical fiber[11].

■ MLAT3 – connects to the LSMT3 card in the LCS through a DS-3 interface at DS-3 rates over coaxial cable. A broadband UNI tributary version, the **DS3L card**, supports provisionable VPI/VCI mappings to the trunk or aggregate link, allowing ATM cell streams to be aggregated from standard ATM network equipment.

■ MLAT1 – connects to the LSMT1 card in the LCS through an inverse multiplexed interface at 4xDS-1 rates over twisted pair cable.

A single Master Control Shelf can support any combination of MLA cards and broadband tributary cards simultaneously.

A Master Control Shelf can connect to Remote Line Card Shelves in three different ways:

■ Over intermediate reach OC-3 rate multi-mode or single-mode optical fiber distributed by the MLA2.

■ Over 4xDS-1 rate twisted pair cable distributed by the MLAT1 card.

Note: The Master Control Shelf can also connect to the D50 RAM (Remote Access Module) over 4xDS-1 rate twisted pair cable distributed by the MLAT1 card.

■ Over DS-3 rate coaxial cable distributed by the MLAT3 card.

VC Cross-Connection. Broadband tributary cards (DS3L and OC3L) can operate in a second mode to provide Virtual Circuit (VC) cross-connection capabilities. Rather than acting as a connection card to collect traffic from an LCS, the broadband tributary card can act as a unit providing the MCS with a UNI interface. This ATM UNI interface provides a link to other ATM devices such as a second DSLAM (cascading feature).

The VC cross-connection feature allows the broadband tributary cards to function as trunk cards for virtual connections to and from line cards, trunk cards, and other broadband tributary cards. The trunk card acts as a switch instead of a multiplexer for

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[9] The MLA2 card has an intra-office optical interface with a target distance of 1,600 ft.

[10] The MLA2S and OC3L card has an inter-office intermediate reach (short-haul) optical interface with a target distance of 50 Kft.

[11] The MLA2L card has a target distance of 130 shaft.

VC cross-connections. The D50 supports four types of VC cross-connections in addition to trunk card routing:

- Line Card to Broadband Tributary Card.
- Broadband Tributary Card to Broadband Tributary Card.
- Broadband Tributary Card to Trunk Card.
- Line Card to Trunk Card.

Line Card Shelf (LCS)

Figure 1-18 illustrates a fully loaded Line Card Shelf (LCS):
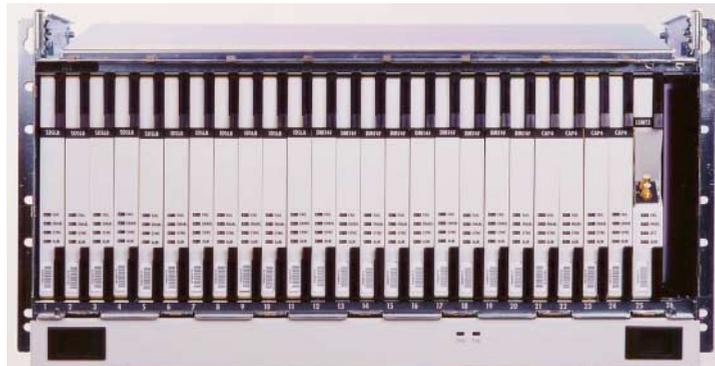
Figure 1-18: D50 Line Card Shelf (LCS8)

Up to twelve Line Card Shelves connect to each Master Control Shelf in a star configuration. They can either be co-located with the MCS, or remotely located. Each Line Card Shelf has 24 mounting slots for line cards, plus slot 25 for the Line Card Shelf multiplexer (LSM2, LSMT1, or LSMT3) and slot 26 for the Remote Craft Access Unit.

The LCS design organizes the cards into groups of six, called "six-packs," with each group having its own cabling plan. The cables feature modular connectors, allowing the LCS to be quickly reconfigured and re-cabled if required. Service capacity is 96 lines per shelf with Quad line cards (DS1 only) and 192 lines per shelf with Octal line cards.

The Line Card Shelf Multiplexer (LSM) card statistically multiplexes the signals from the line cards. The LSM card uploads the aggregated data stream to the Master Line Card Adapter (MLA) card on the Master Control Shelf, transmitting data over an ATM link. The result is a reliable, star network architecture, with each LSM multiplexing and demultiplexing ATM cell streams for up to 24 line cards installed in the Line Card Shelf.

The D50 supports the following LSM cards:

- LSM2 – connects to the MLA2 card in the MCS through OC-3c interface at OC-3 rates (155 Mbps) over multi-mode optical fiber[12].
- LSM2S – connects to the MLA2S card in the MCS through OC-3c interface at OC-3 rates (155 Mbps) over single-mode intermediate reach fiber[13].

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[12] The LSM2 card has an intra-office optical interface with a target distance of 1,600 ft.

[13] The LSM2S card has an inter-office intermediate reach (short-haul) optical interface with a target distance of 50 Kft.

- LSM2L – connects to the MLA2L card in the MCS over single-mode long-haul optical fiber[14].
- LSMT3 – connects to the MLAT3 card in the MCS through a DS-3 interface at DS-3 rates (45 Mbps) over coaxial cable.
- LSMT1 – connects to the MLAT1 card in the MCS through a 4xDS-1 inverse multi-plexed interface at 4xDS-1 (6.176 Mbps) rates over twisted pair cable.

The CSIP of the Master Control Shelf handles the power supply and alarm functions of up to four LCSs. For each additional group of four LCSs, an Auxiliary CSIP is required.

An LCS has the same layout in both the Central Office and remote applications.

D50 RAM

Figure 1-18 illustrates a fully loaded D50 Remote Access Module (RAM):

Figure 1-19: D50 RAM

The D50 RAM is a small, versatile remote line card shelf supporting up to three 4 or 8-port line cards and one LSM card for a total of 24 lines. Its remoteability provides the ideal solution for cost-effectively extending the reach of DSL services throughout the loop access network.

All D50 line cards (ADSL, IDSL, SDSL, SHDSL and DS1) are supported. The D50 RAM connects to the D50 using an LSM/MLA interface to the MCS in a Central Office.

The D50 RAM can be located in remote locations such as building equipment rooms, Controlled Environmental Vaults (CEVs), outdoor cabinets, remote Central Offices, and multiple-dwelling unit (MDU) environments. It can be installed in standard 23-inch Central Office racks, standard 19-inch computer racks, and can also be wall mounted.

The D50 RAM is environmentally hardened for outdoor installations, and is designed for installation in cabinets with existing Digital Loop Carrier (DLC) systems. It interfaces with DLC systems using existing transmission and cable facilities to enable data over voice services.

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[14] The LSM2L card has a target distance of 130 kft.

D50 Line Cards   The multi-service line card mounting slots support insertion of any D50 line card, including:

- Octal Rate Adaptive ADSL (DMT8a-4) with data rates delivering up to 8 Mbps downstream and 1 Mbps upstream[15].

- Octal Rate Adaptive ADSL (DMT8a-3) with data rates delivering up to 8 Mbps downstream and 1 Mbps upstream.

- Octal SDSL (SDSL8) — 2B1Q interface, includes ATM translation, and multi-rate transmission up to 1.536 Mbps.

- Octal SDSL (SDSL8+) line card supporting 8 ports of symmetric bit-rate transmission using 2B1Q line code. The bit rate is variable and ranges from 144 Kbps to 2.3 Mbps, in 8 Kbps increments. This line card is backward compatible with existing SDSL CPE and includes Autobaud.

- Octal SHDSL (SHDSL8) line card supporting 8 ports of symmetric bit-rate transmission using multi-level Trellis Coded Pulse Amplitude Modulation (TC PAM). The payload rate is variable and has a minimum range of 64 Kbps to over 2.3 Mbps in 64 Kbps increments.

- Quad DS1 line card uses FRF.5 and FRF.8 FR-IWFs (Frame Relay Interworking Functions) to support Frame Relay transmissions, and PPP (Point-to-Point Protocol) to support Ethernet transmissions.

- Octal IDSL (IDSL8) line card supporting 8 ports using 2B1Q line code interface, dedicated 128/144 Kbps.

The **DMT8a-4** and **DMT8a-3** ADSL line card provides Rate Adaptive Asymmetric DSL lines using the Discrete Multi-Tone (DMT) modulation technique. DMT uses Frequency Division Duplex (FDD) multiplexing to transmit data in the 35 kHz to 1.1 MHz frequency spectrum at speeds up to 8 Mbps. It divides the frequency range into 256 discrete bands or bins, each with 4 kHz bandwidth. Each band is independently modulated. The DMT8a-3 line card provides eight ports of ADSL.

The DMT8a-4 and DMT8a-3 line cards support both "full-rate" (G.dmt) and "lite" (G.lite) ADSL, provisionable on an individual port basis. In each mode, bins 0 through 7 are reserved for POTS and the remaining bins are used for data. Key differences between G.dmt and G.lite for the DMT8a-3 line card are shown in

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[15] The DMT8a-4 line card also supports speeds up to 10.8 Mbps in 32 Kbps increments in Interleave Mode based on "S=1/2" from the ITU-T G992.1 standard, when used in conjunction with an "S=1/2"-compliant CPE.

Table 1-2: DMT8a-3 — G.lite and G.dmt

	G.lite	**G.dmt**
Splitter required at customer premises?	No	Yes

Transmission rate:
   - Downstream
   - Upstream
	up to 1.5 Mbps
	up to 512 Kbps
		up to 8.0 Mbps
		up to 1.0 Mbps

- Frequency Spectrum Used - Number of Highest Bin Used	25 to 552 kHz 127	25 KHz to 1.1 MHz 256

The **SDSL8** and **SDSL8**+ Octal SDSL line cards use 2B1Q (2 Binary, 1 Quaternary) line encoding technique. This is a DSL line encoding technique that uses four variations in amplitude and polarity to represent two bits. The **SHDSL8** Octal line cards use multi-level Trellis Coded Pulse Amplitude Modulation (TC PAM) in compliance with ITU-T Recommendation G.991.2. Higher rates and better loop reach can be obtained by SHDSL, while maintaining spectral compliance. The SHDSL8, SDSL8 and SDSL8+ line cards use the entire frequency spectrum for data transmission—unlike the ADSL line cards, which can carry both data and analog voice transmissions.

The **DS1** line card allows operators or service providers to provide T1 leased line replacement services over the ATM based DSLAM network. The DS1 Quad line card provides:

- FR-IWF Mode.
    - The DS1 line card terminates Frame Relay and translates the payload into ATM cells per FRF.8 for Frame Relay/ATM Service Interworking.
    - The DS1 line card provides Frame Relay Interworking by encapsulating Frame Relay frames into ATM cells per FRF.5 for Frame Relay/ATM Network Inter-working.
    - FR-IWF is provisionable for either FRF.8 mode or FRF.5 Mode on a connection by connection basis.

The DS1 line card also supports transport of ATM traffic from a customer premises site. The DS1 card is connected to the local loop through the Operator's DSX panel and the typical connection to the customer premises is through a T1 span-line link (repeated T1 link). This allows the DS1 unit greater reach than DSL based line technologies so it can support both Frame Relay and ATM services over distances greater than 18Kft from the CO.

The **IDSL8** Octal IDSL line card implements frame-based protocol Interworking Functions (IWFs) to perform the ATM Segment and Reassembly (SAR) function at the IDSL8 line card. This allows IDSL subscribers to use their existing ISDN CPE. ISDL channels support two different types of Interworking Functions (IWFs): Point to Point over High-level Data Link Control and Frame Relay.

- Point to Point (PPP) over High-level Data Link Control (HDLC):
  - PPP over HDLC, Logical Link Control (LLC) encapsulated.
  - PPP over HDLC, Virtual Channel (VC) multiplexed.
- Frame Relay interworking:
  - Frame Relay (FRF.8) translated over HDLC. Includes PPP over Frame Relay, LLC encapsulated.
  - Frame Relay (FRF.5) one-to-one multiplexed over HDLC.
  - Frame Relay (FRF.5) many-to-one multiplexed over HDLC.
  - Frame Relay PPP Virtual Channel (VC) multiplexed only.

A Permanent Virtual Connection (PVC) must be established to connect the trunk interface VPI/VCI with the IDSL line card port to transport data to and from the IDSL frame-based CPE. The IDSL8 line card supports eight ports, and supports BERT loopback tests and an ISDN Repeaters Count test.

Power Supply Options	D50 nodes are powered by Central Office battery (-48 volts DC). The Central Office battery is connected to the D50 at the Master Control Shelf (MCS) Common Systems Interface Panel (CSIP) Power and Distribution Board.

The D50 has two DC power inputs (Battery 'A' and Battery 'B'). Each of these inputs is capable of supplying power to the D50 during Central Office maintenance operations. The D50 requires -42.75 to -56.0 VDC Central Office power. Battery 'A' and 'B' power inputs are fused at 15 amps for -48 VDC operation.

The CSIP Power and Distribution Board distributes -48 VDC Central Office power to the MCS and to a maximum of four Line Card Shelves in a standard single relay rack configuration. Auxiliary CSIP Power and Distribution Boards are required to distribute power to each additional relay rack configuration of up to four Line Card Shelves per rack.

Product List

Table 1-3: D50 Product List

Master Control Shelf	
MCS	Master Control Shelf Assembly
MCP	Master Control Processor
NMP	Network Management Processor
MTU	Master Timing Unit
DS3T	ATM Trunk Interface card, coaxial cable, electrical interface
DS3T2	ATM Trunk Interface card, coaxial cable, electrical interface, with priority queuing QoSV4
DS3TQ	ATM Trunk Interface card, coaxial cable, electrical interface, with ATM QoS
OC3T	ATM Trunk Interface card, intermediate reach
OC3T2	ATM Trunk Interface card, intermediate reach, with priority queuing QoSV4
OC3T2L	ATM Trunk Interface card, long-haul fiber optic, with priority queuing QoSV4
OC3T2M	ATM Trunk Interface card, multi-mode fiber interface, with priority queuing QoSV4
OC3TQL	ATM Trunk Interface card, long-haul fiber optic, with ATM QoS
OC3TQM	ATM Trunk Interface card, multi-mode fiber interface, with ATM QoS
OC3TQS	ATM Trunk Interface card, short-haul fiber interface (intermediate reach), with ATM QoS
MLA2	Master Line Card Shelf Adapter SONET OC-3c, multi-mode fiber, with priority queuing QoSV4
MLA2S	Master Line Card Shelf Adapter SONET OC-3c, single-mode fiber, intermediate reach, with priority queuing QoSV4
MLA2L	Master Line Card Shelf Adapter SONET OC-3c, single-mode long-haul fiber, with priority queuing QoSV4
MLAT3	Master Line Card Shelf Adapter DS-3 interface, coaxial cable, with priority queuing QoSV4
MLAT1	Master Line Card Shelf Adapter DS-1 interface, twisted pair cable, with priority queuing QoSV4

Table 1-3: D50 Product List (continued)

DS3L	Master Line Card Shelf Adapter (tributary version) DS-3 interface, coaxial cable, supports provisionable VPI/VCI mappings to the trunk or aggregate link
OC3L	Master Line Card Shelf Adapter (tributary version) SONET OC-3c, single-mode fiber, intermediate reach, supports provisionable VPI/VCI mappings to the trunk or aggregate link
Line Card Shelf	
LCS	Line Card Shelf Assembly
D50 RAM	Remote Access Module (three line card slots – multi-service)
LSM2	Line Card Shelf MUX, SONET OC-3c, multi-mode fiber
LSM2S	Line Card Shelf MUX, SONET OC-3c, single-mode fiber, intermediate reach
LSM2L	Line Card Shelf MUX, SONET OC-3c, single-mode long-haul fiber
LSMT3	Line Card Shelf MUX, DS-3 interface, coaxial cable
LSMT1	Line Card Shelf MUX, 4xDS-1 inverse multiplexed interface, twisted pair cable
Line Cards	
DMT8a-4	Octal ADSL DMT-series cards; including G.lite and G.dmt
DMT8a-3	Octal ADSL DMT-series cards; including G.lite and G.dmt
DS1	Quad DS1 card; provides FRF.5 and FRF.8 FR-IWFs (Frame Relay Interworking Functions) to support Frame Relay transmissions, and PPP (Point-to-Point Protocol) to support Ethernet transmissions
IDSL8	Octal IDSL card (dedicated 128/144 Kbps)
SDSL8	Octal SDSL card (up to 1.536 Mbps)
SDSL8+	Octal SDSL card (up to 2.3 Mbps per port)
SHDSL8	Octal SHDSL card (up to 2.3 Mbps per port)
Low Pass Filter Cards	
LPF8-2	Low Pass Filter card T1.413i2 compliant for DMT8-2, DMT8a-3, and DMT8a-4 line cards
LPF8M	Low Pass Filter card DMT8a-3 line cards installed in D50 RAM
MRTC	Through connect LPF plug replacement card for D50 RAM

Table 1-3: D50 Product List (continued)

Software
D50 System Software
D50 Craft Terminal Software
Customer Documents

D50 Documentation CD:
    Volumes 1–6 (General Information, Installation, Commissioning, Provisioning,
        Maintenance and Testing, Craft Terminal)
    D50/D50e Administration Utilities — User's Guide

Miscellaneous / Accessories
EMI Filter Ferrite (for DS-1 cables) EMI Filter Ferrite (for Power and Ethernet cables) PAM8 (Pair Analysis Module) card — The PAM8 card installs in the D50 LCS to provide test continuity of cable pairs (tip/ring) from the D50 to the MDF. CAM8 (Complimentary Analysis Module) card — The CAM8 card installs in the D50 LPFS to provide the pathway to do the continuity tests from the voice switch to the MDF. Remote Craft Access Unit (RCAU) card — The RCAU installs in slot 26 of a remote line card shelf to provide a remote interface for the craft application.

Technical Specifications

Table 1-4: General Specifications

General Specifications	
ATM Layer	
Connection type	PVC
Traffic class	UBR, UBR+, VBR-rt, VBR-nrt, CBR
AAL5	Supports EPD, PPD, EFCI
AAL1	CBR traffic
DSL Ports	
Number per LCS	192
Number per system	2304[1]
Power Supply and Consumption	
Battery voltage	Nominal -48 VDC Absolute limits -42.75... -56.0 VDC
Power consumption	One MCS fully equipped[2] 229 W One LCS fully equipped[3] 396 W
Environment	
Relative humidity	0 to 95% (non-condensing)
Temperature	Central Office installation: 0 to +50°C
Standards – Environmental	GR-63-CORE (Central Office) TR-57 (Outside Plant)
Standards – Electrical	FCC Part 15 Class A

[1] Equipped with 8-port line cards.

[2] Equipped with DS3TQ and MLA2 cards.

[3] Equipped with DMT8a-3 line cards.

Interfaces

Table 1-5: D50 Interfaces

ATM Trunk Interface	
Type	DS-3: electrical interface or OC-3: multi-mode or OC-3: single-mode, intermediate reach or OC-3: single-mode, long haul
Connector	BNC 75 ohm socket connectors (DS3) Duplex SC (OC-3)
Nominal bit rate	155 520 Kbps—OC-3 44 736 Kbps—DS-3
Standards—OC-3	GR-253-CORE, Synchronous Optical Network SONET Transport System, Issue 2, December 1995
Standards—DS-3	GR-499-CORE, TR-TSV-000773, ANSI T1.107-1995, ANSI T1.102-1993
Standards—ATM payload	GR-2842-CORE, TR-NWT-01112
Interface between MCS – LCS (MCS – D50 RAM)	
MLA2/LSM2	
Type	62.5/125 µm multi-mode fiber
Connector	Duplex SC
Nominal bit rate	155 520 Kbps
Standard	(as trunk card)
MLA2S/LSM2S	
Type	9/125 µm single-mode fiber, Intermediate Reach
Connector	Duplex SC
Nominal bit rate	155 520 Kbps
Standard	(as trunk card)
MLAT3/LSMT3	
Type	DS-3
Connector	Coax 75Ω
Nominal bit rate	45 Mbps
MLAT1/LSMT1	

Table 1-5: D50 Interfaces (continued)

Type	4 x DS-1
Connector	2 x RJ45
Nominal bit rate	4 * 1544 Kbps
ATM UNI User Interface	
Type	9/125 µm single-mode fiber, Intermediate Reach
Connectors	SC
Speed	155 520 Kbps
Type	DS-3
Connector	Coax 75Ω
Speed	45 Mbps
ADSL Interface	
Type	ITU.T G992.1 and G992.2 compliant G.DMT, G.lite
DMT – Speed	1024 Kbps – 8.1 Mbps downstream; up to 1024 Kbps upstream
G.lite – Speed	Up to 1536 Kbps downstream; up to 512 Kbps upstream
Type	ITU-T Annex C supporting G.992.1 and G.992.2.
DMT – Speed	FBM: ■ 2.8 Mbps downstream ■ 384 Kbps upstream
G.lite – Speed	DBM: ■ 3.7 Mbps downstream ■ 800 Kbps upstream FBM: ■ 1.8 Mbps downstream ■ 384 Kbps upstream
SHDSL Interface	
Type	Symmetric bit-rate transmission using Multi-level Trellis Coded Pulse Amplitude Modulation (TC PAM).
Speed – SHDSL8	64 Kbps to 2304 Kbps, in 64 Kbps increments

Table 1-5: D50 Interfaces (continued)

SDSL Interface	
Type	Symmetric connection with 2B1Q linecode over single pair
Speed – SDSL8	192 Kbps, 384 Kbps, 768 Kbps, 1152 Kbps and 1536 Kbps
Speed – SDSL8+	144 Kbps to 2.3 Mbps, in 8 Kbps increments
IDSL Interface	
Type	Frame-based protocol Interworking Functions with 2B1Q linecode technique and standard ISDN transceivers with 2B + D framing
Speed – IDSL8	128 Kbps/144 Kbps dedicated
DS1 Interface	
Type	Frame-based protocol Interworking Functions to ATM supporting FRF.5 and FRF.8
Speed – DS1	1.536 Mbps (over the existing T1 link)
Network Management Interface	
Type	10BaseT Ethernet or inband ATM PVC
Protocol	SNMPv1
Connector	RJ-45
Craft Terminal Serial Interface	
Type	RS-232 or 10BaseT Ethernet
Connector	D9F or RJ-45
Speed	■ 38400 baud (serial connection) ■ 10 Mbps (10BaseT Ethernet connection)

Craft Terminal – System Requirements

Table 1-6: D50 Craft Terminal – Minimum System Requirements

Requirement	Description
Operating System	▪ Microsoft Windows NT Workstation 4.0 - or - ▪ Windows 2000
Computer	PC capable of running the required versions of Microsoft Windows (Pentium®[1] recommended)
RAM	32 MB recommended
Hard disk space	6 MB for Craft Terminal software (and at least 20 MB of free disk space after installation)
CD-ROM drive	Standard
Display	VGA compatible (Super VGA recommended)
Pointing device	Microsoft Windows compatible mouse or pointing device
Printer (optional)	Microsoft Windows compatible printer
Interface ports	▪ Serial port ▪ Ethernet port (optional)

[1] Pentium is a registered trademark of Intel Corporation in the United States and other countries.

Chapter 2
D50 System Specifications

NEBS Level 3 Verification

The D50 has been verified by Bellcore for all 33 of the Level 3 Network Equipment Building System (NEBS) requirements.

Electrical Safety Standards

D50 elements conform, as applicable, to the following electrical safety standards:

Bellcore
- GR-1089-CORE, *Electromagnetic Compatibility and Electrical Safety.*
- GR-49-CORE, *Generic Requirements for Outdoor Telephone Network Interface Devices.*

Underwriters Laboratories (UL)
- UL 497 Protectors for Paired Conductor Communications Circuits.
- UL 1459 Telephone Equipment.
- UL 1863 Communication Circuit Accessories.
- UL 1950 Information Technology Equipment Including Electrical Business Equipment (Second Edition).

Mechanical Safety Standards

D50 elements conform to all applicable mechanical and physical safety standards contained within the following documents:
- GR-63-CORE, *Network Equipment-Building System (NEBS) Requirements: Physical Protection,* Issue 1.
- TR-NWT-000078, *Generic Physical Design Requirements for Telecommunications Products and Equipment,* Issue 3.
- GR-49-CORE, *Generic Requirements for Outdoor Telephone Network Interface Devices.*

Performance Parameters

D50 performance parameters meet or exceed standards for bit rate ranges on loops that meet Revised Resistance Design (RRD) guidelines and Carrier Serving Area CSA requirements. These standards are met on all D50 supported line card types: ADSL (DMT), SHDSL, SDSL, DS1, and IDSL.

> **Note:** Various line conditions can affect data rates, such as noise, bridged taps, and crosstalk interference.

Environmental Requirements

The Master Control Shelf (MCS) is Central Office equipment. It conforms to all the environmental requirements contained in GR-63-CORE. Line Card Shelves co-located with the MCS also conform to GR-63-CORE.

Remote Line Card Shelves operate within the outside plant environmental requirements contained in TR-57.

Installation Location	Relative Humidity	Temperature Range	
		Lower Limit	**Upper Limit**
Central Office (LCS)	0 to 95% (non-condensing)	0° C (32° F)	+50° C (122° F)
Remote Site (RLCS)	0 to 95% (non-condensing)	–40° C (–40° F)	+65° C (149° F)

Reliability and Quality Specifications

The D50 multiplexer conforms to the applicable requirements of the following reliability and quality specifications:

Bellcore

- TR-NWT-000057 Functional Criteria for DLC Systems
- GR-63-CORE Network Equipment-Building Systems (NEBS) Requirements
- TR-NWT-000078 Generic Physical Design Requirements
- TR-NWT-000179 Quality System Generic Requirements for Software
- GR-209-CORE Generic Requirements for Product Change Notices
- TA-TSY-000228 Generic Human Factors Requirements for Network Terminal Equipment, Preliminary
- GR-282-CORE Software Reliability and Quality Acceptance Criteria
- TR-NWT-000284 Reliability and Quality Switching Systems Generic Requirements
- GR-326-CORE Generic Requirements for Single-Mode Optical Fiber Connectors
- TR-332 Reliability Prediction Procedure for Electronic Equipment
- TR-NWT-000357 Generic Requirements for Assuring the Reliability of Components Used in Telecommunications Systems
- TR-STS-000383 Generic Requirements for Common Language Bar Code Labels
- TR-TSY-000389 Supplier Data Program Analysis
- TR-NWT-000418 Generic Reliability Assurance Requirements for Fiber Optic Transport Systems
- TR-TSY-000454 Supplier Documentation for Network Elements
- TR-NWT-000468 Reliability Assurance Practices for Optoelectronic Devices in Central Office Applications
- GR-485-CORE Common Language Equipment Coding Processed and Guidelines, Generic Requirements
- GR-499-CORE Transport Systems Generic Requirements (TSGR)
- FR-796 Reliability and Quality Generic Requirements (RQGR)
- GR-839-CORE Generic Requirements for Supplier-Provided Training
- TR-NWT-000840 Electrostatic Discharge Control in the Manufacture of Telecommunications Equipment

- GR-929-CORE Reliability and Quality Measurements for Telecommunications Systems
- TR-NWT-000930 Generic Requirements for Hybrid Microcircuits Used in Telecommunications Equipment
- TA-NWT-000942 Hardware Reliability Assurance Program (H-RAP) Generic Requirements for Telecommunications Products
- SR-TSY-000963 Network Switching Element Outage Performance Monitoring Procedures
- TA-NWT-000983 Reliability Assurance Practices for Optoelectronic Devices in Loop Applications
- TR-NWT-001037 Statistical Process Control Program Generic Requirements
- GR-1089-CORE Electromagnetic Compatibility and Electrical Safety – Generic Criteria for Network Telecommunications Equipment
- SR-TSY-001171 Methods and Procedures for System Reliability Analysis
- GR-1217-CORE Generic Requirements for Separable Electrical Connectors Used in Telecommunications Hardware
- GR-1252-CORE Quality System Generic Requirements for Hardware

International Standards Organization (ISO)

- ISO 9001Quality Systems – Model for Quality Assurance in Design, Development, Production, Installation and Servicing

Underwriters Laboratories (UL)

- UL 497 Protectors for Paired Conductor Communications Circuits
- UL 1459 Telephone Equipment
- UL 1863 Communication Circuit Accessories
- UL 1950 Information Technology Equipment Including Electrical Business Equipment (Second Edition)

D50 Hardware Physical Specifications

Table 1-7: D50 Assembly Dimensions

Assembly	Height (in.)	Depth (in.)	Body Width (in.)	Width w/ Mounting Flanges (in.)	Weight Empty	Weight Fully Loaded
MCS	14.38	12.00	21.25	23.37	45 lbs	74 lbs
Aux CSIP	6.90	10.00	21.26	23.00	12 lbs	----
LCS	12.13	12.00	21.25	23.37	32 lbs	65 lbs
LPFS8	10.40	12.00	21.26	23.26	29 lbs	48 lbs
D50 RAM	5.25	12.00	19.00	23.37	16 lbs	24 lbs

The D50 multiplexer is designed for mounting in a standard telco relay rack. The drawing below shows mounting heights for the Master Control Shelf, Line Card Shelf and Low Pass Filter Shelf (LPFS8) to support ADSL data plus voice applications.

Note: A single telco relay rack supports the following configurations:
- 1 MCS and 2 LCSs with 2 LPFS8s.
- 1 Auxiliary CSIP and 3 LCSs with 3 LPFS8s.
- 1 MCS and 4 LCSs.
- 1 Auxiliary CSIP and 4 LCSs.

NOTES:

1 PRE-INSTALL SHELF MOUNTING SCREWS
   IN LOCATIONS SHOWN TO TAKE ADVANTAGE
   OF KEYHOLE SLOTS TO AID INSTALLATION.

2. LEAVE ABOUT 1/4 INCH CLEARANCE BETWEEN
   RACK AND HEAD OF MOUNTING SCREW.

3. INSTALL SHELVES FROM BOTTOM UP. LOWEST
   UNIT IN RACK IS INSTALLED FIRST.

71.250   (MCS)

59.000   (LCS #1)

46.750   (LPFS8 #1)

36.250   (LCS #2)

10X 1

24.000   (LPFS8 #2)

.000
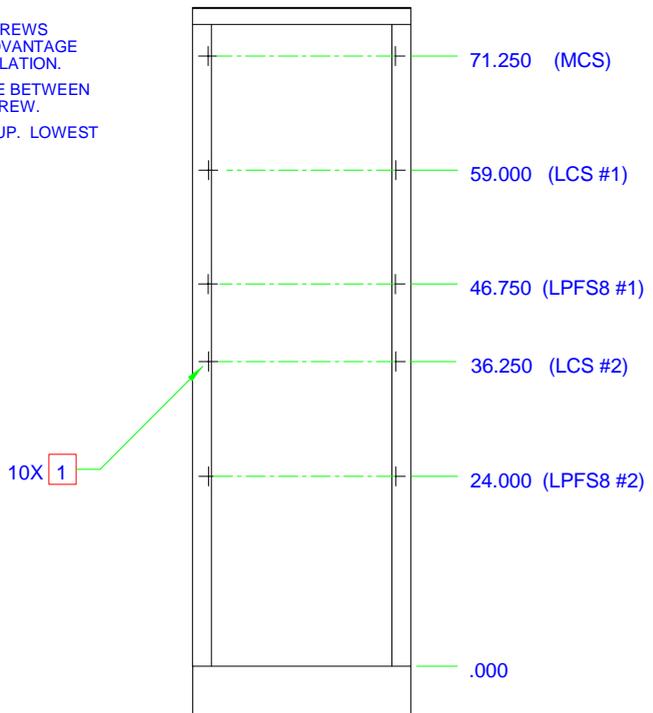
Figure 1-20: D50 Mounting Heights—MCS, LCSs and LPFSs

NOTES:

1 PRE-INSTALL SHELF MOUNTING SCREWS
   IN LOCATIONS SHOWN TO TAKE ADVANTAGE
   OF KEYHOLE SLOTS TO AID INSTALLATION.

2. LEAVE ABOUT 1/4 INCH CLEARANCE BETWEEN
   RACK AND HEAD OF MOUNTING SCREW.

3. INSTALL SHELVES FROM BOTTOM UP. LOWEST
   UNIT IN RACK IS INSTALLED FIRST.

4. THIS CONFIGURATION REQUIRES 43 RACK
   UNITS OF USABLE SPACE IN THE RACK
   (1 RACK UNIT = 1.75 INCHES).

14X 1

73.000 (AUX. CSIP)

67.750 (LCS #1)

55.500 (LPFS8 #1)

45.000 (LCS #2)

32.750 (LPFS8 #2)

22.250 (LCS #3)

10.000 (LPFS8 #3)

.000
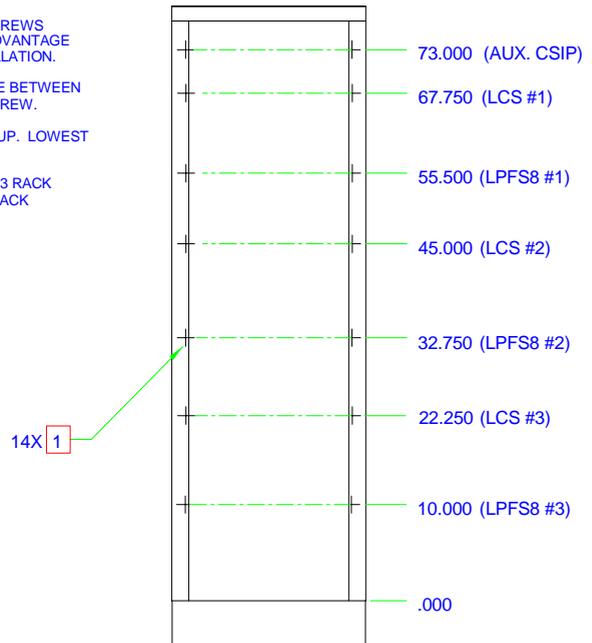
Figure 1-21: D50 Mounting Heights — AUX CSIP, LCSs & LPFSs

The drawing below shows mounting heights for the Master Control Shelf and Line Card Shelves to support ADSL, SDSL, SHDSL, DS1, and IDSL data only applications (no LPFS required).

NOTES:

1. PRE-INSTALL SHELF MOUNTING SCREWS IN LOCATIONS SHOWN TO TAKE ADVANTAGE OF KEYHOLE SLOTS TO AID INSTALLATION.

2. LEAVE ABOUT 1/4 INCH CLEARANCE BETWEEN RACK AND HEAD OF MOUNTING SCREW.

3. INSTALL SHELVES FROM BOTTOM UP. LOWEST UNIT IN RACK IS INSTALLED FIRST.

10X 1

71.250 (MCS)

59.000 (LCS #1)

46.750 (LCS #2)

34.500 (LCS #3)

22.250 (LCS #4)

.000
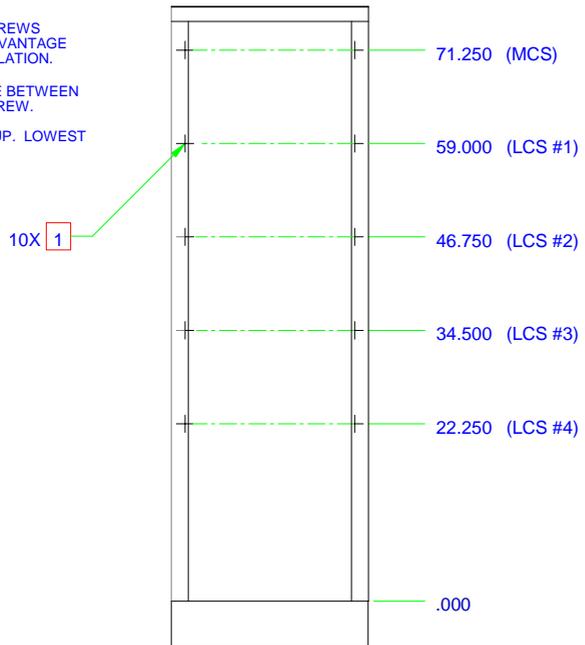
Figure 1-22: D50 Mounting Heights—MCS and LCSs

The drawing below shows mounting heights for the Auxiliary CSIP and Line Card Shelves to support ADSL, SDSL, SHDSL, DS1, and IDSL data only applications (no LPFS required).

NOTES:

1. PRE-INSTALL SHELF MOUNTING SCREWS IN LOCATIONS SHOWN TO TAKE ADVANTAGE OF KEYHOLE SLOTS TO AID INSTALLATION.

2. LEAVE ABOUT 1/4 INCH CLEARANCE BETWEEN RACK AND HEAD OF MOUNTING SCREW.

3. INSTALL SHELVES FROM BOTTOM UP. LOWEST UNIT IN RACK IS INSTALLED FIRST.

73.000   (AUX CSIP)

67.750   (LCS #1)

55.500   (LCS #2)

43.250   (LCS #3)

10X 1

31.000   (LCS #4)

.000
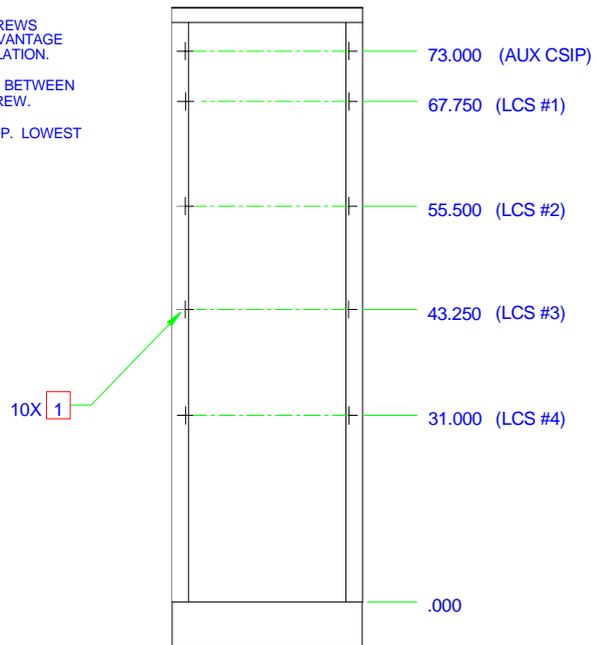
Figure 1-23: D50 Mounting Heights — AUX CSIP, and LCSs

The D50 multiplexer design requires front and rear access for ATM network, telco and power cabling.
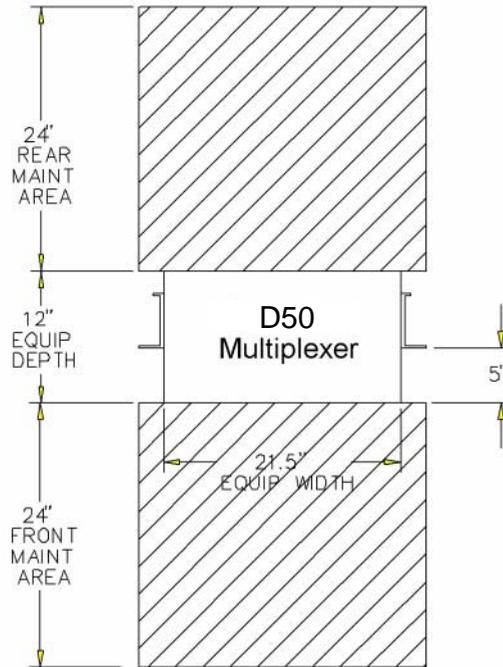
Figure 1-24: D50 in a Telco Relay Rack — Top View

D50 Multiplexer Capacities   The following table lists the assemblies that make up a D50 multiplexer, and the maximum capacity of each assembly:

Table 1-8: D50 Multiplexer Capacities

Assembly	Card Type	Maximum Count
MCS	Master Timing Unit	2
	Network Management Processor (NMP)	1
	Master Control Processor (MCP)	2
	ATM Network Interface: - DS3T, DS3T2 or DS3TQ, or - OC3T, OC3T2, OC3T2M, OC3T2L, OC3TQL, OC3TQM, or OC3TQS	2
	Broadband Interface: - MLA2 or MLA2S - MLA2L - MLAT1 - MLAT3 - OC3L - DS3L	12
LCS	Line Cards: - DMT8a-3 - DMT8a-4 - SHDSL8 - SDSL8 - SDSL8+ - DS1 - IDSL8	24
	Line Card Shelf Multiplexer[1] (LSM): - LSM2 or LSM2S - LSM2L - LSMT1 - LSMT3	1
	- RCAU (Remote Craft Access Unit)	1 (in addition to LSM)
LPFS8	- LPF8-2[2]	24

Table 1-8: D50 Multiplexer Capacities (continued)

Assembly	Card Type	Maximum Count
D50 RAM	Line Cards: - DMT8a-3 - DMT8a-4 - SHDSL8 - SDSL8 - SDSL8+ - DS1 - IDSL8	3
	Line Card Shelf Multiplexer (LSM): - LSMT1	1
	Low Pass Filter (LPF) or Through Connect Cards: - LPF8M - MRTC	3

[1] LSM cards are installed in slot 25. The RCAU card is installed in slot 26.

[2] The Low Pass Filter card is T1.413i2 compliant for DMT8a-3 line cards.

Customer Premises Equipment Interoperability

The Nokia D50 platform is interoperable with a wide and diverse range of Customer Premises Equipment (CPE) supporting ADSL (G.dmt and G.lite), SDSL, SHDSL, DS1 and IDSL.

A full list of the CPE that the D50 is interoperable with can be obtained by contacting Nokia Broadband Systems sales personnel.

Chapter 3
ATM Network Element Interface

Hardware Requirements and Version Compatibility

The D50 supports two network interfaces: DS-3 and OC-3c, each carrying ATM payload. The D50 fully conforms to the following requirements for DS3 network interface:

- ANSI, T1.404-1994, *Network-to-Customer Installation – DS3 Metallic Interface Specification*.
- ANSI, T1.102-1993, *Digital Hierarchy – Electrical Interfaces*.

Software Interface Specifications

Network Interface Facilities. The D50 fully conforms to the following software requirements for DS-3 network interface:

- Bellcore, GR-499-CORE, Issue 1, December 1995.
- Bellcore, TR-TSV-000773, Issue 1, June 1991, Revision 1, January 1993.
- ANSI T1.107-1995 *Digital Hierarchy – Formats Specifications*.

For OC-3c network interface, the applicable standards are:

- Bellcore, GR-253-CORE, Synchronous Optical Network SONET Transport System, Issue 2, December 1995.

With respect to the ATM payload, the D50 conforms to:

- Bellcore, GR-2842-CORE, ATM Service Access Multiplexer (SAM) Generic Criteria, Issue 1, Revision 1.
- Bellcore, TR-NWT-01112, Broadband ISDN User to Network Interface and Network Node Interface Physical Layer Criteria.

The D50 will fully conform to the ATM Forum's UNI Traffic Management Specification Version 4.0 in the future. The D50 Quality of Service (QoS) implementation supports CBR (Continuous Bit Rate), VBR-rt (Variable Bit Rate real-time), VBR-nrt (Variable Bit Rate non-real-time), UBR (Unspecified Bit Rate), and UBR+ (Unspecified Bit Rate with minimum cell rate guarantee) service classes.

**Operations
System
Interfaces**

The D50 multiplexer supports north bound interfaces to an OSS (Operations Support System) via gateways provided by a management system. Gateways include Bellcore-compliant GR-833 CORE TLI and a CORBA 2.0 IDL for the D50 network elements.

Technical specifications:

- OMG 2.0 CORBA specifications.
- Bellcore GR-833 CORE—"Network Element and Transport Surveillance Messages."
- Bellcore GR-2869 CORE General Requirements

SECTION 2 PLANNING AND ENGINEERING

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Chapter 1
Planning

DSL Loop Qualification

DSL requires a non-loaded loop that conforms to the North American Revised Resistance Design (RRD) rules; i.e., a loop within 18,000 feet from the Central Office. A large percentage of existing non-loaded loops, that conform to North American Revised Resistance Design (RRD) rules, will successfully carry DSL traffic.

DSL for Unqualified Loops. There are ways of providing DSL service to customers served by loops that do not conform to the RRD rules, or to customers served by loops long enough to affect data rate performance. There are two possible solutions to these problems: a Remote Line Card Shelf (LCS), or digital loop carriers with a Remote LCS.

DSL Compatibility Issues. There are two potential compatibility issues that may affect DSL service: ISDN and HDSL. ISDN and HDSL interference within a binder group may reduce effective DSL data rates on a given loop. Rate adaptive ADSL will adjust the data rate on the loop to accommodate interference.

D50 Power Cabling

The D50 multiplexer is powered by Central Office battery (-48 volts DC). Central Office battery is connected to the D50 at the Master Control Shelf (MCS) Common Systems Interface Panel (CSIP) Power and Distribution Board.

The D50 has two DC power inputs (Battery 'A' and Battery 'B'). Each of these inputs is capable of supplying power to the D50 during Central Office maintenance operations. The recommended gauge wire for power cabling is 8 AWG. The D50 requires -42.75 to -56.0 VDC Central Office power. Battery 'A' and 'B' power inputs are fused at 15 amps for -48 VDC operation.

The CSIP Power and Distribution Board distributes -48 VDC Central Office power to the MCS and to a maximum of four Line Card Shelves in a standard single relay rack configuration. Auxiliary CSIP Power and Distribution Boards are required to distribute power to each additional relay rack configuration of up to four Line Card Shelves per rack.

Line Card Shelf power cabling is fully connectorized. 14 AWG cables are shipped with the D50.

ATM Network Cabling	**DS-3 ATM Network.** WECO 728A equivalent coaxial cables with 75-ohm BNC socket connectors are run from the DSX-3 cross connect panel to the D50 Master Control Shelf. "Transmit" and "Receive" trunk cables are routed through a cable port at the back or side of the MCS, and terminated on BNC "pin" connectors mounted on the front of the MCS backplane. Data is transferred between the D50 and the ATM network via the DS3T, DS3T2, or DS3TQ trunk card.

OC-3 ATM Network. Single-mode (9/125 micron) optical fiber with SC duplex connectors is run from the Optical Distribution Frame (ODF) to the D50 Master Control Shelf. "Transmit" and "Receive" trunk cables are routed through the front of the MCS card cage, and terminated on inset connectors on the OC3T[3], OC3TQS[3], OC3TQL[1], OC3TQM[2], OC3T2L[1], OCT2TM[2] or OC3T2[3] trunk card faceplate.

MCS to LCS Interface Cabling	**Fiber Optic.** Line Card Shelves are connected to the Master Control Shelf via Line Card Shelf Multiplexer (LSM2, LSM2S or LSM2L) cards. Each LSM2 card connects to a Master Line Card Adapter (MLA2, MLA2S or MLA2L) card in the Master Control Shelf. The LSM2 and MLA2 cards exchange signals at OC-3c rate over multi-mode[4]. The LSM2S and MLA2S exchange signals over single-mode fiber optical cable[5]. The LSM2L and MLA2L exchange signals over single-mode long-haul fiber optical cable[6].

Fiber optic cabling is fully connectorized. Multi-mode fiber optic cables (62.5μm diameter) with SC duplex connectors at both ends are provided with each Line Card Shelf shipped.

Coaxial. The LCS can be connected to the MCS via coaxial cable. The LSMT3 in the LCS transfers data to and from the MLAT3 in the MCS over coaxial cable at DS-3 rate.

Copper. The LCS can be connected to the MCS via copper cable/pair. The LSMT1 in the LCS transfers data to and from the MLAT1 in the MCS over copper cable at 4xDS-1 rate.

The Line Card Shelf Multiplexer (LSM) card on the Line Card Shelf (LCS) connects to a Master Line Card Shelf Adapter (MLA) card in the Master Control Shelf (MCS). The following table shows the fiber optic, copper and coaxial connections used between the MLA and the LSM.

---

[1] OC3TQL and OC3T2L trunk cards have an inter-office long-haul optical interface with a target distance of 130 kft.

[2] The OC3T2M and OC3TQM trunk cards have multi-mode optical fiber interfaces with SC duplex connectors and have a target distance of 5 kft.

[3] The OC3T, OC3T2 and OC3TQS trunk cards have an inter-office short-haul optical interface with a target distance of 50 kft.

[4] The MLA2 and LSM2 cards have an intra-office optical interface with a target distance of 1,600 ft.

[5] The OC3L, MLA2S and LSM2S cards have an inter-office short-haul optical interface with a target distance of 50 kft.

[6] The MLA2L and LSM2L cards have an inter-office long-haul optical interface with a target distance of 130 kft.

Table 2-1: MLA to LSM Interface Types

Interface Type	Rate	MLA	Description	
Fiber Optic	OC3	MLA2	62.5/125 µm multi-mode fiber	LSM/LSM2
		MLA2S	9/125 µm single-mode fiber, short haul	LSM2S
		MLA2L	9/125 µm single-mode fiber, long haul	LSM2L
Coaxial	4xDS1	MLAT1	copper cable/pair	LSMT1
Coaxial	DS3	MLAT3	coaxial cable	LSMT3

Table 2-2: OC3 Interface – Optical Power

Optical Power	Multi-Mode	Short Haul Single-Mode	Long Haul Single-Mode
Output – Maximum Average	-14 dBm	-8 dBm	-0 dBm
Output – Minimum Average	-20.5 dBm	-15 dBm	-5 dBm
Input – Maximum Average	-14 dBm	-8 dBm	-10 dBm
Input – Minimum Average	-29 dBm	-28 dBm	-34 dBm

MCS Broadband Tributary Connections

Broadband tributary cards provide a standard ATM UNI interface that supports provisionable VPI/VCI mappings to the D50 trunk card, allowing ATM cells to be aggregated from standard ATM network equipment. The two tributary cards are:

- OC3L – transmits and receives data at OC-3 rate over single-mode fiber optic cable.
- DS3L – transmits and receives data at DS-3 rate over coaxial cable.

Subscriber Line Cabling

The D50 can be configured for ADSL, SHDSL, DS1[7], SDSL, and IDSL data service only, or ADSL data plus voice service, based on the needs of the network service provider. Subscriber line cabling varies, depending on the configuration of the D50.

Data Service Only Configuration. The connection between the local exchange network and the D50 is made at the Line Card Shelf (LCS) backplane. Each LCS is designed for connection to a maximum of one hundred and ninety-two (192) VF cable/pairs at the Main Distribution Frame (MDF).

The LCS cabling plan organizes line cards into four groups of six channel slots, to support a total of 24 octal line cards. Each group of six channel slots interconnects to a single connector on the LCS backplane for ports 1 through 4, and to a second connector on the backplane for ports 5 through 8, required for octal line cards. Refer to the volume titled Installation, Section 6—*Telco Cabling* for detailed information on line card cabling.

Line Card Shelves can be cabled using standard 25 pair cable stubs or using sequential pair cable assemblies.

Cable stubs—round 25 pair cables with a laminated flat end—are shipped with the D50. Each cable stub is equipped with a 50 position female ribbon connector on the flat end, and a 50 position Amp Champ female connector on the round cable end. The flat end of the 25 pair cable stub connects to the LCS backplane. The round end of the cable stub connects to a 25 pair[8] cable which is connected to subscriber lines at the MDF.

Data only service can also be cabled using sequential pair cabling. The Sequential Pair Cable assembly connects all eight ports on a line card from the LCS to the MDF. The cable assembly has two cable "branches" on both ends. A D50 with one LCS and 24 octal line cards requires four sequential pair cable assemblies—one assembly for each six-pack. Please refer to Section 6—*Telco Cabling*, Chapter 3—"LCS Cabling—Octal Line Cards (Data Only): Sequential Pair Cabling," page 6-41 in the volume titled Installation for detailed information.

Data plus Voice Configuration. When the D50 is configured for ADSL data plus voice service, the connection between the local exchange network and the D50 is made at the Low Pass Filter Shelf (LPFS8) backplane. Data plus voice frequency signals are received from the customer at the Low Pass Filter Shelf. The Low Pass Filter (LPF8-2) card "splits" the low frequency voice signal from the high frequency data signal. The voice signal is sent onto the switch unimpeded—the data signal is received by the line card. Each LPFS8 is designed for connection to a maximum of 192 VF cable/pairs at the Main Distribution Frame (MDF).

---

[7] The DS1 line card supports ATM over DS1 service, including packetized voice over T1 (DS1) lines.

[8] The network service provider may choose to run 100 pair VF cables from the MDF to the D50.

The Low Pass Filter Shelf cabling plan organizes up to 24 Low Pass Filter cards into groups of six channel slots. Cabling for the LPFS8 (for use with LCSs supporting <u>octal</u> ADSL line cards) is as follows:

- Each group of six cards requires <u>six</u> connections on the LPFS8 backplane:
  - Connections One and Two: <u>Data</u> signals are sent to and received from the line card. These connections are made at the LPFS8 and LCS backplanes.
  - Connections Three and Four: <u>Data plus voice</u> signals are sent to and received from the subscriber. These connections between the LPFS8 and the local exchange network are made at the LPFS8 backplane and the MDF.
  - Connections Five and Six: <u>Voice</u> signals are sent to and received from the voice switch. These connections between the LPFS8 and the switch are made at the LPFS8 backplane and the MDF.

LPFS8s can be cabled using standard 25 pair cable stubs or using sequential pair cable assemblies.

- Cabling with standard 25 pair cable stubs.

  LPFS8 to LCS cabling is fully connectorized. One end of the 25 pair cable is connected to the LPFS8 backplane the other end connects to its corresponding connector on the Line Card Shelf backplane.

  LFPS8 to MDF *subscriber* cable stubs, round 25 pair cables with a laminated flat end, are shipped with the D50. Cable stubs are equipped with a 50 position female ribbon connector on the flat end, and a 50 position Amp Champ female connector on the round cable end. The flat end of the 25 pair cable stub connects to the LPFS8 backplane. The round end of the cable stub connects to a 25 pair[9] cable which is connected to subscriber lines at the MDF.

  LPFS8 to MDF *switch* cable stubs, round 25 pair cables with a laminated flat end, are shipped with the D50. Cable stubs are equipped with a 50 position female ribbon connector on the flat end, and a 50 position Amp Champ female connector on the round cable end. The flat end of the 25 pair cable stub connects to the LPFS8 backplane. The round end of the cable stub connects to a 25 pair[9] cable which is connected to the central office switch at the MDF.

  For detailed LPFS8 cabling instructions to set up data plus voice service using standard 25 pair cable studs, see the volume titled <u>Installation</u>, Chapter 5—"LPFS8 Cabling—Octal Line Cards (Data Plus Voice)."

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[9] The network service provider may choose to run 100 pair VF cables from the MDF to the D50.

■ Sequential Pair Cabling.

Sequential pair cabling is fully connectorized. The sequential pair cable assembly connects all eight ports on an LPF8-2 card from the LPFS8 to the IDF. The cable assembly has two cable "branches" on both ends. The flat ribbon ends of the cable assembly connects to two connectors on the LPFS8 backplane; the round Amp Champ ends of the cable connect to two IDF cables.

Each sequential pair cable connects up to eight ports on up to six LPF8-2 cards to six line cards at the LCS (through the IDF). For example: A system ordered with one LCS, one LPFS8, 24 Octal line cards, and 24 LPF8-2 cards requires a total of four sequential pair cable assemblies—one cable assembly (with two connectors on both ends) for each group of six line cards (six-pack).

For detailed LPFS8 cabling instructions to set up data plus voice service using sequential pair cabling, see the volume titled <u>Installation</u>, Chapter 6—"LPFS8 Cabling—Octal Line Cards (Data Plus Voice): Sequential Pair Cabling."

D50 RAM Cabling	**Power Cabling.** The D50 RAM (Remote Access Module) is powered by -48 volts DC battery, which is connected to the D50 RAM at the power connector board. The recommended gauge wire for power cabling is 18 AWG.

MCS to D50 RAM Connection. The D50 RAM is connected to the Master Control Shelf via a Line Card Shelf Multiplexer (LSMT1) card. The LSMT1 card connects to and transfers data to and from a Master Line Card Adapter (MLAT1) card in the Master Control Shelf over copper cable at 4xDS-1 rate.

Subscriber Line Cabling. The D50 RAM supports ADSL, SHDSL, DS1, SDSL, and IDSL data service only, or ADSL data plus voice service, based on the needs of the network service provider. The D50 RAM is designed for connection to a maximum of twenty-four (24) VF cable/pairs.

Data Service Only Configuration. The connection between the local exchange network and the D50 RAM is made at the line cards with a single connector on the front of the connector board: data signals are sent to and received from the local loop.

Data plus Voice Configuration. The connection between the local exchange network and the D50 RAM is made at the low pass filter (LPF) cards with two connectors on the front of the connector boards:

■ Data signals are sent to and received from the local loop (Loop/DSL).

■ Data plus voice signals are sent to and received from the Public Switched Network (PSTN/POTS).

The LPF card "splits" the low frequency voice signal from the high frequency data signal. The voice signal is sent onto the switch unimpeded—the data signal is received by the line card.

**Hardware
Assemblies**

The Master Control Shelf (MCS) looks like this:
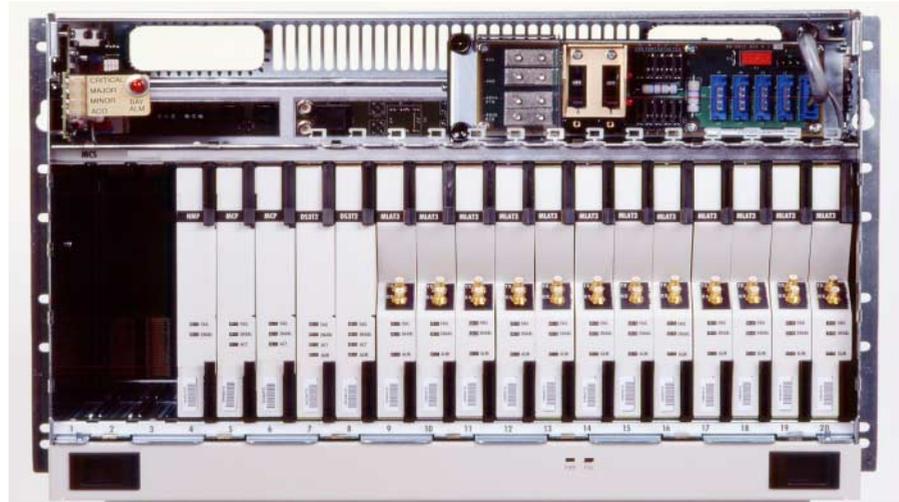
Figure 2-1: Master Control Shelf Assembly

The Line Card Shelf (LCS) looks like this:
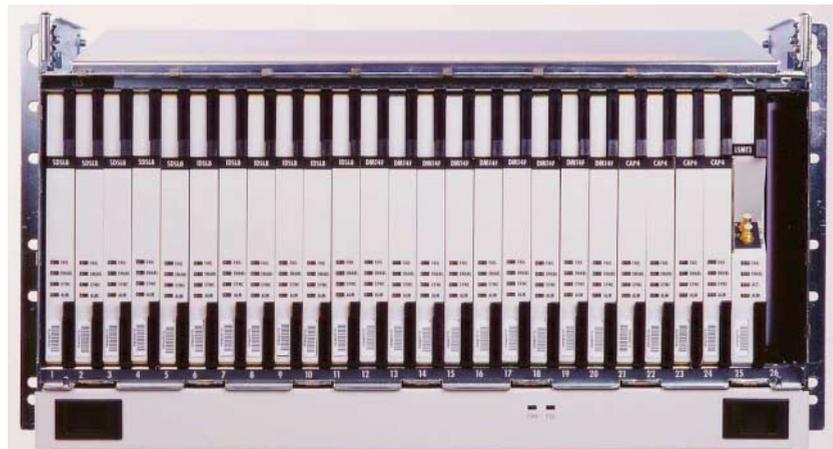
Figure 2-2: Line Card Shelf Assembly

The Low Pass Filter Shelf (LPFS8) assembly looks like this:
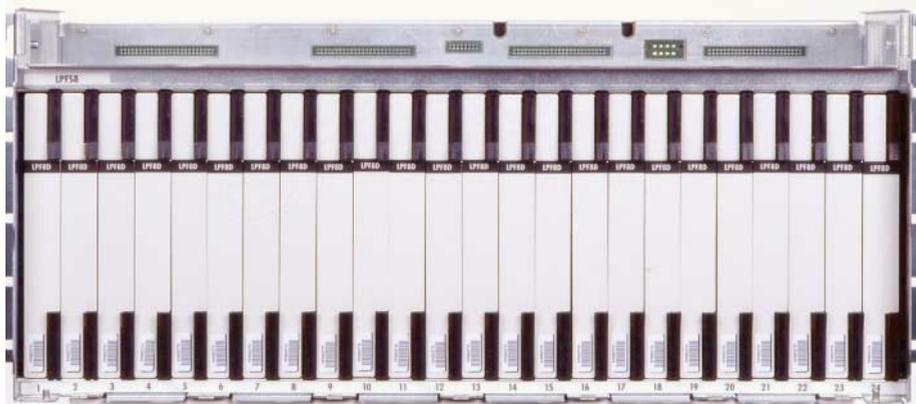
Figure 2-3: Low Pass Filter Shelf Assembly

The D50 RAM assembly looks like this:
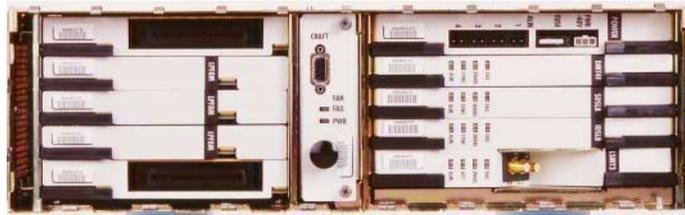
Figure 2-4: D50 RAM Assembly

Power Consumption	Power consumption for line cards is not use-sensitive in the current release. In the future, the D50 may implement a power management scheme that would reduce power consumption when the circuit is not actively in use. See the Power Consumption charts in the following chapter.

General Power Requirements

The MCS and LCS require -48 VDC power that meets the TR-57 electrical power supply standards.

The Low Pass Filter Shelf (LPFS) contains only passive devices and requires no power.

The Auxiliary CSIP requires -48 VDC to distribute power to up to four line card shelves (LCS).

The D50 RAM requires -48 VDC power or 120VAC 60Hz power that meets the TR-57 electrical power supply standards.

MCS Power Consumption Charts

The following tables show power consumption requirements for the different card combinations in the Master Control Shelf:

Table 2-3: MCS with DS3T/DS3T2 & MLA2/MLA2S/MLA2L/OC3L Cards

		TOTAL WATTS (7.0 per MLA2, MLA2S, MLA2L, or OC3L card)											
		1	2	3	4	5	6	7	8	9	10	11	12
		MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L
1 NMP 1 MCP 1 DS3T/DS3T2 Fan Tray	(7.2 W) (6.0 W) (10.8 W) (30.0 W)	61.0	68.0	75.0	82.0	89.0	96.0	103.0	110.0	117.0	124.0	131.0	138.0
1 NMP 1 MCP 2 DS3T/DS3T2 Fan Tray	(7.2 W) (6.0 W) (21.6 W) (30.0 W)	72.0	79.0	86.0	93.0	100.0	107.0	114.0	121.0	128.0	135.0	142.0	149.0
1 NMP 2 MCPs 1 DS3T/DS3T2 Fan Tray	(7.2 W) (12.0 W) (10.8 W) (30.0 W)	67.0	74.0	81.0	88.0	95.0	102.0	109.0	116.0	123.0	130.0	137.0	144.0
1 NMP 2 MCPs 2 DS3T/DS3T2 Fan Tray	(7.2 W) (12.0 W) (21.6 W) (30.0 W)	78.0	85.0	92.0	99.0	106.0	113.0	120.0	127.0	134.0	141.0	148.0	155.0

Table 2-4: MCS with DS3T/DS3T2 and MLAT3 or DS3L Cards

		TOTAL WATTS (7.0 per MLAT3 or DS3L card)											
		1	2	3	4	5	6	7	8	9	10	11	12
		MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L
1 NMP (7.2 W) 1 MCP (6.0 W) 1 DS3T/DS3T2 (10.8 W) Fan Tray (30.0 W)		61	68	75	82	89	96	103	110	117	124	131	138
1 NMP (7.2 W) 1 MCP (6.0 W) 2 DS3T/DS3T2 (21.6 W) Fan Tray (30.0 W)		72	79	86	93	100	107	114	121	128	135	142	149
1 NMP (7.2 W) 2 MCPs (12.0 W) 1 DS3T/DS3T2 (10.8 W) Fan Tray (30.0 W)		67	74	81	88	95	102	109	116	123	130	137	144
1 NMP (7.2 W) 2 MCPs (12.0 W) 2 DS3T/DS3T2 (21.6 W) Fan Tray (30.0 W)		78	85	92	99	106	113	120	127	134	141	148	155

Table 2-5: MCS with DS3T/DS3T2 and MLAT1 Cards

		TOTAL WATTS (7.0 per MLAT1 card)											
		1	2	3	4	5	6	7	8	9	10	11	12
		MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1
1 NMP (7.2 W) 1 MCP (6.0 W) 1 DS3T/DS3T2 (10.8 W) Fan Tray (30.0 W)		61	68	75	82	89	96	103	110	117	124	131	138
1 NMP (7.2 W) 1 MCP (6.0 W) 2 DS3T/DS3T2 (21.6 W) Fan Tray (30.0 W)		72	79	86	93	100	107	114	121	128	135	142	149
1 NMP (7.2 W) 2 MCPs (12.0 W) 1 DS3T/DS3T2 (10.8 W) Fan Tray (30.0 W)		67	74	81	88	95	102	109	116	123	130	137	144
1 NMP (7.2 W) 2 MCPs (12.0 W) 2 DS3T/DS3T2 (21.6 W) Fan Tray (30.0 W)		78	85	92	99	106	113	120	127	134	141	148	155

Table 2-6: MCS with DS3TQ and MLA2, MLA2S or OC3L Cards

		TOTAL WATTS (7.0 per MLA2, MLA2S, MLA2L, or OC3L card)											
		1	2	3	4	5	6	7	8	9	10	11	12
		MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L
1 NMP (7.2 W) 1 MCP (6.0 W) 1 DS3TQ (47.0 W) Fan Tray (30.0 W)		97	104	111	118	125	132	139	146	153	160	167	174
1 NMP (7.2 W) 1 MCP (6.0 W) 2 DS3TQ (94.0 W) Fan Tray (30.0 W)		144	151	158	165	172	179	186	193	200	207	214	221
1 NMP (7.2 W) 2 MCPs (12.0 W) 1 DS3TQ (47.0 W) Fan Tray (30.0 W)		105	112	119	126	133	140	147	154	161	168	175	182
1 NMP (7.2 W) 2 MCPs (12.0 W) 2 DS3TQ (94.0 W) Fan Tray (30.0 W)		152	159	166	173	180	187	194	201	208	215	222	229

Table 2-7: MCS with DS3TQ and MLAT3 or DS3L Cards

		TOTAL WATTS (7.0 per MLAT3 or DS3L card)											
		1	2	3	4	5	6	7	8	9	10	11	12
		MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L
1 NMP (7.2 W) 1 MCP (6.0 W) 1 DS3TQ (47.0 W) Fan Tray (30.0 W)		97	104	111	118	125	132	139	146	153	160	167	174
1 NMP (7.2 W) 1 MCP (6.0 W) 2 DS3TQ (94.0 W) Fan Tray (30.0 W)		144	151	158	165	172	179	186	193	200	207	214	221
1 NMP (7.2 W) 2 MCPs (12.0 W) 1 DS3TQ (47.0 W) Fan Tray (30.0 W)		103	110	117	124	131	138	145	152	159	166	173	180
1 NMP (7.2 W) 2 MCPs (12.0 W) 2 DS3TQ (94.0 W) Fan Tray (30.0 W)		150	157	164	171	178	185	192	199	206	213	220	227

Table 2-8: MCS with DS3TQ and MLAT1 Cards

		TOTAL WATTS (7.0 per MLAT1 card)											
		1	2	3	4	5	6	7	8	9	10	11	12
		MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1
1 NMP (7.2 W) 1 MCP (6.0 W) 1 DS3TQ (47.0 W) Fan Tray (30.0 W)		97	104	111	118	125	132	139	146	153	160	167	174
1 NMP (7.2 W) 1 MCP (6.0 W) 2 DS3TQ (94.0 W) Fan Tray (30.0 W)		144	151	158	165	172	179	186	193	200	207	214	221
1 NMP (7.2 W) 2 MCPs (12.0 W) 1 DS3TQ (47.0 W) Fan Tray (30.0 W)		103	110	117	124	131	138	145	152	159	166	173	180
1 NMP (7.2 W) 2 MCPs (12.0 W) 2 DS3TQ (94.0 W) Fan Tray (30.0 W)		150	157	164	171	178	185	192	199	206	213	220	227

Table 2-9: MCS with OC3T2[1] and MLA2/MLA2S/MLA2L/OC3L Cards

		TOTAL WATTS (7.0 per MLA2, MLA2S, MLA2L, or OC3L)											
		1	2	3	4	5	6	7	8	9	10	11	12
		MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L	MLA2, MLA2S, MLA2L or OC3L
1 NMP (7.2 W) 1 MCP (6.0 W) 1 OC3T/OC3T2 (15.5 W) Fan Tray (30.0 W)		66	73	80	87	94	101	108	115	122	129	136	143
1 NMP (7.2 W) 1 MCP (6.0 W) 2 OC3T/OC3T2 (31.0 W) Fan Tray (30.0 W)		81	88	95	102	109	116	123	130	137	144	151	158
1 NMP (7.2 W) 2 MCP (12.0 W) 1 OC3T/OC3T2 (15.5 W) Fan Tray (30.0 W)		72	79	86	93	100	107	114	121	128	135	142	149
1 NMP (7.2 W) 2 MCP (12.0 W) 2 OC3T/OC3T2 (31.0 W) Fan Tray (30.0 W)		87	94	101	108	115	122	129	136	143	150	157	164

[1] Applicable for OC3T2L and OC3T2M trunk cards.

Table 2-10: MCS with OC3T2[1] and MLAT3 or DS3L

		TOTAL WATTS (7.0 per MLAT3 or DS3L)											
		1	2	3	4	5	6	7	8	9	10	11	12
		MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L
1 NMP (7.2 W) 1 MCP (6.0 W) 1 OC3T/OC3T2 (15.5 W) Fan Tray (30.0 W)		66	73	80	87	94	101	108	115	122	129	136	143
1 NMP (7.2 W) 1 MCP (6.0 W) 2 OC3T/OC3T2 (31.0 W) Fan Tray (30.0 W)		81	88	95	102	109	116	123	130	137	144	151	158
1 NMP (7.2 W) 2 MCPs (12.0 W) 1 OC3T/OC3T2 (15.5 W) Fan Tray (30.0 W)		72	79	86	93	100	107	114	121	128	135	142	149
1 NMP (7.2 W) 2 MCP (12.0 W) 2 OC3T/OC3T2 (31.0 W) Fan Tray (30.0 W)		87	94	101	108	115	122	129	136	143	150	157	164

[1] Applicable for OC3T2L and OC3T2M trunk cards.

Table 2-11: MCS with OC3T, OC3T2[1] and MLAT1 Cards

		TOTAL WATTS (7.0 per MLAT1 card)											
		1	2	3	4	5	6	7	8	9	10	11	12
		MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1
1 NMP (7.2 W) 1 MCP (6.0 W) 1 OC3T/OC3T2 (15.5 W) Fan Tray (30.0 W)		66	73	80	87	94	101	108	115	122	129	136	143
1 NMP (7.2 W) 1 MCP (6.0 W) 2 OC3T/OC3T2 (31.0 W) Fan Tray (30.0 W)		81	88	95	102	109	116	123	130	137	144	151	158
1 NMP (7.2 W) 2 MCPs (12.0 W) 1 OC3T/OC3T2 (15.5 W) Fan Tray (30.0 W)		72	79	86	93	100	107	114	121	128	135	142	149
1 NMP (7.2 W) 2 MCPs (12.0 W) 2 OC3T/OC3T2 (31.0 W) Fan Tray (30.0 W)		87	94	101	108	115	122	129	136	143	150	157	164

[1] Applicable for OC3T2L and OC3T2M trunk cards.

Table 2-12: MCS with OC3TQ[1] and MLA2, MLA2S or OC3L Cards

		TOTAL WATTS (7.0 per MLA2, MLA2S or OC3L card)											
		1	2	3	4	5	6	7	8	9	10	11	12
		MLA2, MLA2S or OC3L	MLA2, MLA2S or OC3L	MLA2, MLA2S or OC3L	MLA2, MLA2S or OC3L	MLA2, MLA2S or OC3L	MLA2, MLA2S or OC3L	MLA2, MLA2S or OC3L	MLA2, MLA2S or OC3L	MLA2, MLA2S or OC3L	MLA2, MLA2S or OC3L	MLA2, MLA2S or OC3L	MLA2, MLA2S or OC3L
1 NMP (7.2 W) 1 MCP (6.0 W) 1 OC3TQ (47.0 W) Fan Tray (30.0 W)		97	104	111	118	125	132	139	146	153	160	167	174
1 NMP (7.2 W) 1 MCP (6.0 W) 2 OC3TQ (94.0 W) Fan Tray (30.0 W)		144	151	158	165	172	179	186	193	200	207	214	221
1 NMP (7.2 W) 2 MCPs (12.0 W) 1 OC3TQ (47.0 W) Fan Tray (30.0 W)		103	110	117	124	131	138	145	152	159	166	173	180
1 NMP (7.2 W) 2 MCPs (12.0 W) 2 OC3TQ (94.0 W) Fan Tray (30.0 W)		150	157	164	171	178	185	192	199	206	213	220	227

[1] Applicable for OC3TQL, OC3TQM, and OC3TQS trunk cards.

Table 2-13: MCS with OC3TQ[1] and MLAT3 or DS3L Cards

		TOTAL WATTS (7.0 per MLAT3 or DS3L card)											
		1	2	3	4	5	6	7	8	9	10	11	12
		MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L	MLAT3 or DS3L
1 NMP (7.2 W) 1 MCP (6.0 W) 1 OC3TQ (47.0 W) Fan Tray (30.0 W)		97	104	111	118	125	132	139	146	153	160	167	174
1 NMP (7.2 W) 1 MCP (6.0 W) 2 OC3TQ (94.0 W) Fan Tray (30.0 W)		144	151	158	165	172	179	186	193	200	207	214	221
1 NMP (7.2 W) 2 MCPs (12.0 W) 1 OC3TQ (47.0 W) Fan Tray (30.0 W)		103	110	117	124	131	138	145	152	159	166	173	180
1 NMP (7.2 W) 2 MCPs (12.0 W) 2 OC3TQ (94.0 W) Fan Tray (30.0 W)		150	157	164	171	178	185	192	199	206	213	220	227

[1] Applicable for OC3TQL, OC3TQM, and OC3TQS trunk cards.

Table 2-14: MCS with OC3TQ[1] and MLAT1 Cards

| | | TOTAL WATTS (7.0 per MLAT1 card) | | | | | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
		MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1	MLAT1
1 NMP 1 MCP 1 OC3TQ Fan Tray	(7.2 W) (6.0 W) (47.0 W) (30.0 W)	97	104	111	118	125	132	139	146	153	160	167	174
1 NMP 1 MCP 2 OC3TQ Fan Tray	(7.2 W) (6.0 W) (94.0 W) (30.0 W)	144	151	158	165	172	179	186	193	200	207	214	221
1 NMP 2 MCPs 1 OC3TQ Fan Tray	(7.2 W) (12.0 W) (47.0 W) (30.0 W)	103	110	117	124	131	138	145	152	159	166	173	180
1 NMP 2 MCPs 2 OC3TQ Fan Tray	(7.2 W) (12.0 W) (94.0 W) (30.0 W)	150	157	164	171	178	185	192	199	206	213	220	227

[1] Applicable for OC3TQL, OC3TQM, and OC3TQS trunk cards.

MTU Power Consumption   The Master Timing Unit (MTU) card's power consumption is approximately 2 watts.

LCS Power Consumption Charts with LSM2 Cards

The following tables show power consumption requirements for the different card combinations in the Line Card Shelf:

Table 2-15: LCS with LSM2, LSM2S, or LSM2L and DMT8a-4 Cards

Total DMT8a-4 line cards	1	2	3	4	5	6	7	8	9	10	11	12
DMT8a-4 Card Watts	13.0	26.0	39.0	52.0	65.0	78.0	91.0	104.0	117.0	130.0	143.0	156.0
LSM2 Watts	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
Fan Tray Watts	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TOTAL WATTS	**62.2**	**75.2**	**88.2**	**101.2**	**114.2**	**127.2**	**140.2**	**153.2**	**166.2**	**179.2**	**192.2**	**205.2**

Total DMT8a-4 line cards	13	14	15	16	17	18	19	20	21	22	23	24
DMT8a-4 Card Watts	169.0	182.0	195.0	208.0	221.0	234.0	247.0	260.0	273.0	286.0	299.0	312.0
LSM2 Watts	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
Fan Tray Watts	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TOTAL WATTS	**218.2**	**231.2**	**244.2**	**257.2**	**270.2**	**283.2**	**296.2**	**309.2**	**322.2**	**335.2**	**348.2**	**361.2**

Note: 13.0 W per DMT8a-4 card represents typical power consumption. Lower rates (and G.lite mode) require less power.

Table 2-16: LCS with LSM2, LSM2S, or LSM2L and DMT8a-3 Cards

Total DMT8a-3 line cards	1	2	3	4	5	6	7	8	9	10	11	12
DMT8a-3 Card Watts	16.5	33.0	49.5	66.0	82.5	99.0	115.5	132.0	148.5	165.0	181.5	198.0
LSM2 Watts	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
Fan Tray Watts	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TOTAL WATTS	**65.7**	**82.2**	**98.7**	**115.2**	**131.7**	**148.2**	**164.7**	**181.2**	**197.7**	**214.2**	**230.7**	**247.2**

Total DMT8a-3 line cards	13	14	15	16	17	18	19	20	21	22	23	24
DMT8a-3 Card Watts	214.5	231.0	247.5	264.0	280.5	297.0	313.5	330.0	346.5	363.0	379.5	396.0
LSM2 Watts	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
Fan Tray Watts	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TOTAL WATTS	**263.7**	**280.2**	**296.7**	**313.2**	**329.7**	**346.2**	**362.7**	**379.2**	**395.7**	**412.2**	**428.7**	**445.2**

Note: 16.5 W per DMT8a-3 card represents typical power consumption. Lower rates (and G.lite mode) require less power. G.lite is 15.8 W per card.

Table 2-17: LCS with LSM2, LSM2S, or LSM2L and SHDSL8 Cards

Total SHDSL8 line cards	1	2	3	4	5	6	7	8	9	10	11	12
SHDSL8 Card Watts	14	28	42	56	70	84	98	112	126	140	154	168
LSM2 Watts	19	19	19	19	19	19	19	19	19	19	19	19
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**63**	**77**	**91**	**105**	**119**	**133**	**147**	**161**	**175**	**189**	**203**	**217**

Total SHDSL8 line cards	13	14	15	16	17	18	19	20	21	22	23	24
SHDSL8 Card Watts	182	196	210	224	238	252	266	280	294	308	322	336
LSM2 Watts	19	19	19	19	19	19	19	19	19	19	19	19
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**231**	**245**	**259**	**273**	**287**	**301**	**315**	**329**	**343**	**357**	**371**	**385**

Note: 14.0 W per SHDSL8 card represents power consumption at maximum (2.3 Mbps) rate. Lower rates require less power.

Table 2-18: LCS with LSM2, LSM2S, or LSM2L and SDSL8 Cards

Total SDSL8 line cards	1	2	3	4	5	6	7	8	9	10	11	12
SDSL8 Card Watts	14	28	42	56	70	84	98	112	126	140	154	168
LSM2 Watts	19	19	19	19	19	19	19	19	19	19	19	19
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**63**	**77**	**91**	**105**	**119**	**133**	**147**	**161**	**175**	**189**	**203**	**217**

Total SDSL8 line cards	13	14	15	16	17	18	19	20	21	22	23	24
SDSL8 Card Watts	182	196	210	224	238	252	266	280	294	308	322	336
LSM2 Watts	19	19	19	19	19	19	19	19	19	19	19	19
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**231**	**245**	**259**	**273**	**287**	**301**	**315**	**329**	**343**	**357**	**371**	**385**

Note: 14.0 W per SDSL8 card represents power consumption at maximum (1.536 Mbps) rate. Lower rates require less power.

Table 2-19: LCS with LSM2, LSM2S, or LSM2L and SDSL8+ Cards

Total SDSL8+ line cards	1	2	3	4	5	6	7	8	9	10	11	12
SDSL8+ Card Watts	12	24	36	48	60	72	84	96	108	120	132	144
LSM2 Watts	19	19	19	19	19	19	19	19	19	19	19	19
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**61**	**73**	**85**	**97**	**109**	**121**	**133**	**145**	**157**	**169**	**181**	**193**

Total SDSL8+ line cards	13	14	15	16	17	18	19	20	21	22	23	24
SDSL8+ Card Watts	156	168	180	192	204	216	228	240	252	264	276	288
LSM2 Watts	19	19	19	19	19	19	19	19	19	19	19	19
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**205**	**217**	**229**	**241**	**253**	**265**	**277**	**289**	**301**	**313**	**325**	**337**

Note: 12.0 W per SDSL8+ card represents power consumption at maximum rate. Lower rates require less power.

Table 2-20: LCS with LSM2, LSM2S, or LSM2L and DS1 Cards

Total DS1 line cards	1	2	3	4	5	6	7	8	9	10	11	12
DS1 Card Watts	11	22	33	44	55	66	77	88	99	110	121	132
LSM2 Watts	19	19	19	19	19	19	19	19	19	19	19	19
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**60**	**71**	**82**	**93**	**104**	**115**	**126**	**137**	**148**	**159**	**170**	**181**

Total DS1 line cards	13	14	15	16	17	18	19	20	21	22	23	24
DS1 Card Watts	143	154	165	176	187	198	209	220	231	242	253	264
LSM2 Watts	19	19	19	19	19	19	19	19	19	19	19	19
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**192**	**203**	**214**	**225**	**236**	**247**	**258**	**269**	**280**	**291**	**302**	**313**

Table 2-21: LCS with LSM2, LSM2S, or LSM2L and IDSL8 Cards

Total IDSL8 line cards	1	2	3	4	5	6	7	8	9	10	11	12
IDSL8 Card Watts	8	15	23	30	38	45	53	60	68	75	83	90
LSM2 Watts	19	19	19	19	19	19	19	19	19	19	19	19
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**57**	**64**	**72**	**79**	**87**	**94**	**102**	**109**	**117**	**124**	**132**	**139**

Total IDSL8 line cards	13	14	15	16	17	18	19	20	21	22	23	24
IDSL8 Card Watts	98	105	113	120	128	135	143	150	158	165	173	180
LSM2 Watts	19	19	19	19	19	19	19	19	19	19	19	19
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**147**	**154**	**162**	**169**	**177**	**184**	**192**	**199**	**207**	**214**	**222**	**229**

LCS Power Consumption Charts with LSMT1 Cards

Table 2-22: LCS with LSMT1 and DMT8a-4 Cards

Total DMT8a-4 line cards	1	2	3	4	5	6	7	8	9	10	11	12
DMT8a-4 Card Watts	13.0	26.0	39.0	52.0	65.0	78.0	91.0	104.0	117.0	130.0	143.0	156.0
LSMT1 Watts	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
Fan Tray Watts	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TOTAL WATTS	**60.0**	**73.0**	**86.0**	**99.0**	**112.0**	**125.0**	**138.0**	**151.0**	**164.0**	**177.0**	**190.0**	**203.0**

Total DMT8a-4 line cards	13	14	15	16	17	18	19	20	21	22	23	24
DMT8a-4 Card Watts	169.0	182.0	195.0	208.0	221.0	234.0	247.0	260.0	273.0	286.0	299.0	312.0
LSMT1 Watts	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
Fan Tray Watts	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TOTAL WATTS	**216.0**	**229.0**	**242.0**	**255.0**	**268.0**	**281.0**	**294.0**	**307.0**	**320.0**	**333.0**	**346.0**	**359.0**

Table 2-23: LCS with LSMT1 and DMT8a-3 Cards

Total DMT8a-3 line cards	1	2	3	4	5	6	7	8	9	10	11	12
DMT8a-3 Card Watts	16.5	33.0	49.5	66.0	82.5	99.0	115.5	132.0	148.5	165.0	181.5	198.0
LSMT1 Watts	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
Fan Tray Watts	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TOTAL WATTS	**63.5**	**80.0**	**96.5**	**113.0**	**129.5**	**146.0**	**162.5**	**179.0**	**195.5**	**212.0**	**228.5**	**245.0**

Total DMT8a-3 line cards	13	14	15	16	17	18	19	20	21	22	23	24
DMT8a-3 Card Watts	214.5	231.0	247.5	264.0	280.5	297.0	313.5	330.0	346.5	363.0	379.5	396.0
LSMT1 Watts	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
Fan Tray Watts	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TOTAL WATTS	**261.5**	**278.0**	**294.5**	**311.0**	**327.5**	**344.0**	**360.5**	**377.0**	**393.5**	**410.0**	**426.5**	**443.0**

Note: 16.5 W per DMT8a-3 card represents typical power consumption. Lower rates (and G.lite mode) require less power. G.lite is 15.8 W per card.

Table 2-24: LCS with LSMT1 and SHDSL8 Cards

Total SHDSL8 line cards	1	2	3	4	5	6	7	8	9	10	11	12
SHDSL8 Card Watts	14	28	42	56	70	84	98	112	126	140	154	168
LSMT1 Watts	17	17	17	17	17	17	17	17	17	17	17	17
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**61**	**75**	**89**	**103**	**117**	**131**	**145**	**159**	**173**	**187**	**201**	**215**

Total SHDSL8 line cards	13	14	15	16	17	18	19	20	21	22	23	24
SHDSL8 Card Watts	182	196	210	224	238	252	266	280	294	308	322	336
LSMT1 Watts	17	17	17	17	17	17	17	17	17	17	17	17
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**229**	**243**	**257**	**271**	**285**	**299**	**313**	**327**	**341**	**355**	**369**	**383**

Note: 14.0 W per SHDSL8 card represents power consumption at maximum (2.3 Mbps) rate. Lower rates require less power.

Table 2-25: LCS with LSMT1 and SDSL8 Cards

Total SDSL8 line cards	1	2	3	4	5	6	7	8	9	10	11	12
SDSL8 Card Watts	14	28	42	56	70	84	98	112	126	140	154	168
LSMT1 Watts	17	17	17	17	17	17	17	17	17	17	17	17
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**61**	**75**	**89**	**103**	**117**	**131**	**145**	**159**	**173**	**187**	**201**	**215**

Total SDSL8 line cards	13	14	15	16	17	18	19	20	21	22	23	24
SDSL8 Card Watts	182	196	210	224	238	252	266	280	294	308	322	336
LSMT1 Watts	17	17	17	17	17	17	17	17	17	17	17	17
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**229**	**243**	**257**	**271**	**285**	**299**	**313**	**327**	**341**	**355**	**369**	**383**

Note: 14.0 W per SDSL8 card represents power consumption at maximum (1.536 Mbps) rate. Lower rates require less power.

Table 2-26: LCS with LSMT1 and SDSL8+ Cards

Total SDSL8+ line cards	1	2	3	4	5	6	7	8	9	10	11	12
SDSL8+ Card Watts	12	24	36	48	60	72	84	96	108	120	132	144
LSMT1 Watts	17	17	17	17	17	17	17	17	17	17	17	17
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**59**	**71**	**83**	**95**	**107**	**119**	**131**	**143**	**155**	**167**	**179**	**191**

Total SDSL8+ line cards	13	14	15	16	17	18	19	20	21	22	23	24
SDSL8+ Card Watts	156	168	180	192	204	216	228	240	252	264	276	288
LSMT1 Watts	17	17	17	17	17	17	17	17	17	17	17	17
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**203**	**215**	**227**	**239**	**251**	**263**	**275**	**287**	**299**	**311**	**323**	**335**

Note: 12.0 W per SDSL8+ card represents power consumption at maximum rate. Lower rates require less power.

Table 2-27: LCS with LSMT1 and DS1 Cards

Total DS1 line cards	1	2	3	4	5	6	7	8	9	10	11	12
DS1 Card Watts	11	22	33	44	55	66	77	88	99	110	121	132
LSMT1 Watts	17	17	17	17	17	17	17	17	17	17	17	17
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**58**	**69**	**80**	**91**	**102**	**113**	**124**	**135**	**146**	**157**	**168**	**179**

Total DS1 line cards	13	14	15	16	17	18	19	20	21	22	23	24
DS1 Card Watts	143	154	165	176	187	198	209	220	231	242	253	264
LSMT1 Watts	17	17	17	17	17	17	17	17	17	17	17	17
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**190**	**201**	**212**	**223**	**234**	**245**	**256**	**267**	**278**	**289**	**300**	**311**

Table 2-28: LCS with LSMT1 and IDSL8 Cards

Total IDSL8 line cards	1	2	3	4	5	6	7	8	9	10	11	12
IDSL8 Card Watts	8	15	23	30	38	45	53	60	68	75	83	90
LSMT1 Watts	17	17	17	17	17	17	17	17	17	17	17	17
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**55**	**62**	**70**	**77**	**85**	**92**	**100**	**107**	**115**	**122**	**130**	**137**

Total IDSL8 line cards	13	14	15	16	17	18	19	20	21	22	23	24
IDSL8 Card Watts	98	105	113	120	128	135	143	150	158	165	173	180
LSMT1 Watts	17	17	17	17	17	17	17	17	17	17	17	17
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**145**	**152**	**160**	**167**	**175**	**182**	**190**	**197**	**205**	**212**	**220**	**227**

LCS Power Consumption Charts with LSMT3 Cards

Table 2-29: LCS with LSMT3 and DMT8a-4 Cards

Total DMT8a-4 line cards	1	2	3	4	5	6	7	8	9	10	11	12
DMT8a-4 Card Watts	13.0	26.0	39.0	52.0	65.0	78.0	91.0	104.0	117.0	130.0	143.0	156.0
LSMT3 Watts	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Fan Tray Watts	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TOTAL WATTS	**65.0**	**78.0**	**91.0**	**104.0**	**117.0**	**130.0**	**143.0**	**156.0**	**169.0**	**182.0**	**195.0**	**208.0**

Total DMT8a-4 line cards	13	14	15	16	17	18	19	20	21	22	23	24
DMT8a-4 Card Watts	169.0	182.0	195.0	208.0	221.0	234.0	247.0	260.0	273.0	286.0	299.0	312.0
LSMT3 Watts	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Fan Tray Watts	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TOTAL WATTS	**221.0**	**234.0**	**247.0**	**260.0**	**273.0**	**286.0**	**299.0**	**312.0**	**325.0**	**338.0**	**351.0**	**364.0**

Table 2-30: LCS with LSMT3 and DMT8a-3 Cards

Total DMT8a-3 line cards	1	2	3	4	5	6	7	8	9	10	11	12
DMT8a-3 Card Watts	16.5	33.0	49.5	66.0	82.5	99.0	115.5	132.0	148.5	165.0	181.5	198.0
LSMT3 Watts	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Fan Tray Watts	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TOTAL WATTS	**68.5**	**85.0**	**101.5**	**118.0**	**134.5**	**151.0**	**167.5**	**184.0**	**200.5**	**217.0**	**233.5**	**250.0**

Total DMT8a-3 line cards	13	14	15	16	17	18	19	20	21	22	23	24
DMT8a-3 Card Watts	214.5	231.0	247.5	264.0	280.5	297.0	313.5	330.0	346.5	363.0	379.5	396.0
LSMT3 Watts	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Fan Tray Watts	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
TOTAL WATTS	**266.5**	**283.0**	**299.5**	**316.0**	**332.5**	**349.0**	**365.5**	**382.0**	**398.5**	**415.0**	**431.5**	**448.0**

Note: 16.5 W per DMT8a-3 card represents typical power consumption. Lower rates (and G.lite mode) require less power. G.lite is 15.8 W per card.

Table 2-31: LCS with LSMT3 and SHDSL8 Cards

Total SHDSL8 line cards	1	2	3	4	5	6	7	8	9	10	11	12
SHDSL8 Card Watts	14	28	42	56	70	84	98	112	126	140	154	168
LSMT3 Watts	22	22	22	22	22	22	22	22	22	22	22	22
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**66**	**80**	**94**	**108**	**122**	**136**	**150**	**164**	**178**	**192**	**206**	**220**

Total SHDSL8 line cards	13	14	15	16	17	18	19	20	21	22	23	24
SHDSL8 Card Watts	182	196	210	224	238	252	266	280	294	308	322	336
LSMT3 Watts	22	22	22	22	22	22	22	22	22	22	22	22
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**234**	**248**	**262**	**276**	**290**	**304**	**318**	**332**	**346**	**360**	**374**	**388**

Note: 14.0 W per SHDSL8 card represents power consumption at maximum (2.3 Mbps) rate. Lower rates require less power.

Table 2-32: LCS with LSMT3 and SDSL8 Cards

Total SDSL8 line cards	1	2	3	4	5	6	7	8	9	10	11	12
SDSL8 Card Watts	14	28	42	56	70	84	98	112	126	140	154	168
LSMT3 Watts	22	22	22	22	22	22	22	22	22	22	22	22
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**66**	**80**	**94**	**108**	**122**	**136**	**150**	**164**	**178**	**192**	**206**	**220**

Total SDSL8 line cards	13	14	15	16	17	18	19	20	21	22	23	24
SDSL8 Card Watts	182	196	210	224	238	252	266	280	294	308	322	336
LSMT3 Watts	22	22	22	22	22	22	22	22	22	22	22	22
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**234**	**248**	**262**	**276**	**290**	**304**	**318**	**332**	**346**	**360**	**374**	**388**

Note: 14.0 W per SDSL8 card represents power consumption at maximum (1.536 Mbps) rate. Lower rates require less power.

Table 2-33: LCS with LSMT3 and SDSL8+ Cards

Total SDSL8+ line cards	1	2	3	4	5	6	7	8	9	10	11	12
SDSL8+ Card Watts	12	24	36	48	60	72	84	96	108	120	132	144
LSMT3 Watts	22	22	22	22	22	22	22	22	22	22	22	22
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**64**	**76**	**88**	**100**	**112**	**124**	**136**	**148**	**160**	**172**	**184**	**196**

Total SDSL8+ line cards	13	14	15	16	17	18	19	20	21	22	23	24
SDSL8+ Card Watts	156	168	180	192	204	216	228	240	252	264	276	288
LSMT3 Watts	22	22	22	22	22	22	22	22	22	22	22	22
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**208**	**220**	**232**	**244**	**256**	**268**	**280**	**292**	**304**	**316**	**328**	**340**

Note: 12.0 W per SDSL8+ card represents power consumption at maximum rate. Lower rates require less power.

Table 2-34: LCS with LSMT3 and DS1 Cards

Total DS1 line cards	1	2	3	4	5	6	7	8	9	10	11	12
DS1 Card Watts	11	22	33	44	55	66	77	88	99	110	121	132
LSMT3 Watts	22	22	22	22	22	22	22	22	22	22	22	22
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**63**	**74**	**85**	**96**	**107**	**118**	**129**	**140**	**151**	**162**	**173**	**184**

Total DS1 line cards	13	14	15	16	17	18	19	20	21	22	23	24
DS1 Card Watts	143	154	165	176	187	198	209	220	231	242	253	264
LSMT3 Watts	22	22	22	22	22	22	22	22	22	22	22	22
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**195**	**206**	**217**	**228**	**239**	**250**	**261**	**272**	**283**	**294**	**305**	**316**

Table 2-35: LCS with LSMT3 and IDSL8 Cards

Total IDSL8 line cards	1	2	3	4	5	6	7	8	9	10	11	12
IDSL8 Card Watts	8	15	23	30	38	45	53	60	68	75	83	90
LSMT3 Watts	22	22	22	22	22	22	22	22	22	22	22	22
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**60**	**67**	**75**	**82**	**90**	**97**	**105**	**112**	**120**	**127**	**135**	**142**

Total IDSL8 line cards	13	14	15	16	17	18	19	20	21	22	23	24
IDSL8 Card Watts	98	105	113	120	128	135	143	150	158	165	173	180
LSMT3 Watts	22	22	22	22	22	22	22	22	22	22	22	22
Fan Tray Watts	30	30	30	30	30	30	30	30	30	30	30	30
TOTAL WATTS	**150**	**157**	**165**	**172**	**180**	**187**	**195**	**202**	**210**	**217**	**225**	**232**

RCAU Power Consumption   The Remote Craft Access Unit (RCAU) card's power consumption is approximately 1 watt. The RCAU is installed in slot 26 of the LCS.

D50 RAM Power Consumption Charts

The following tables show power consumption requirements for the D50 RAM with the different LSM cards and line cards:

Note: The LSMT1 card (connected to an MLAT1 card in the MCS) is recommended for the D50 RAM. Charts for the LSM2 and the LSMT3 cards are shown for reference.

Table 2-36: D50 RAM with an LSM2 Interface

Total DMT8a-4	1	2	3
DMT8a-4 Card Watts	13	26	39
LSM2 Watts	19	19	19
Fan Tray Watts	6	6	6
TOTAL WATTS	**38**	**51**	**64**

DMT8a-4

Total DMT8a-3	1	2	3
DMT8a-3 Card Watts	16.5	33.0	49.5
LSM2 Watts	19	19	19
Fan Tray Watts	6.0	6.0	6.0
TOTAL WATTS	**41.5**	**58.0**	**74.5**

DMT8a-3

Total SDSL8	1	2	3
SDSL8 Card Watts	14	28	42
LSM2 Watts	19	19	19
Fan Tray Watts	6	6	6
TOTAL WATTS	**39**	**53**	**67**

SDSL8

Total SDSL8+	1	2	3
SDSL8+ Card Watts	12	24	36
LSM2 Watts	19	19	19
Fan Tray Watts	6	6	6
TOTAL WATTS	**37**	**49**	**61**

SDSL8+

Total IDSL8	1	2	3
IDSL8 Card Watts	8	15	23
LSM2 Watts	19	19	19
Fan Tray Watts	6	6	6
TOTAL WATTS	**33**	**40**	**48**

IDSL8

Total SHDSL8	1	2	3
SHDSL8 Card Watts	14	28	42
LSM2 Watts	19	19	19
Fan Tray Watts	6	6	6
TOTAL WATTS	**39**	**53**	**67**

SHDSL8

Total DS1	1	2	3
DS1 Card Watts	11	22	33
LSM2 Watts	19	19	19
Fan Tray Watts	6	6	6
TOTAL WATTS	**36**	**47**	**58**

DS1

Table 2-37: D50 RAM with an LSMT1 Interface

Total DMT8a-4	1	2	3
DMT8a-4 Card Watts	13	26	39
LSMT1 Watts	17	17	17
Fan Tray Watts	6	6	6
TOTAL WATTS	**36**	**49**	**62**

DMT8a-4

Total DMT8a-3	1	2	3
DMT8a-3 Card Watts	16.5	33.0	49.5
LSMT1 Watts	17	17	17
Fan Tray Watts	6.0	6.0	6.0
TOTAL WATTS	**39.5**	**56.0**	**72.5**

DMT8a-3

Total SDSL8	1	2	3
SDSL8 Card Watts	14	28	42
LSMT1 Watts	17	17	17
Fan Tray Watts	6	6	6
TOTAL WATTS	**37**	**51**	**65**

SDSL8

Total SDSL8+	1	2	3
SDSL8+ Card Watts	12	24	36
LSMT1 Watts	17	17	17
Fan Tray Watts	6	6	6
TOTAL WATTS	**35**	**47**	**59**

SDSL8+

Total IDSL8	1	2	3
IDSL8 Card Watts	8	15	23
LSMT1 Watts	17	17	17
Fan Tray Watts	6	6	6
TOTAL WATTS	**31**	**38**	**46**

IDSL8

Total SHDSL8	1	2	3
SHDSL8 Card Watts	14	28	42
LSMT1 Watts	17	17	17
Fan Tray Watts	6	6	6
TOTAL WATTS	**37**	**51**	**65**

SHDSL8

Total DS1	1	2	3
DS1 Card Watts	11	22	33
LSMT1 Watts	17	17	17
Fan Tray Watts	6	6	6
TOTAL WATTS	**34**	**45**	**56**

DS1

Table 2-38: D50 RAM with LSMT3 Interface

Total DMT8a-4	1	2	3
DMT8a-4 Card Watts	13	26	39
LSMT3 Watts	22	22	22
Fan Tray Watts	6	6	6
TOTAL WATTS	**41**	**54**	**67**

DMT8a-4

Total DMT8a-3	1	2	3
DMT8a-3 Card Watts	16.5	33.0	49.5
LSMT3 Watts	22	22	22
Fan Tray Watts	6.0	6.0	6.0
TOTAL WATTS	**44.5**	**61.0**	**77.5**

DMT8a-3

Total SDSL8	1	2	3
SDSL8 Card Watts	14	28	42
LSMT3 Watts	22	22	22
Fan Tray Watts	6	6	6
TOTAL WATTS	**42**	**56**	**70**

SDSL8

Total SDSL8+	1	2	3
SDSL8+ Card Watts	12	24	36
LSMT3 Watts	22	22	22
Fan Tray Watts	6	6	6
TOTAL WATTS	**40**	**52**	**64**

SDSL8+

Total IDSL8	1	2	3
IDSL8 Card Watts	8	15	23
LSMT3 Watts	22	22	22
Fan Tray Watts	6	6	6
TOTAL WATTS	**36**	**43**	**51**

IDSL8

Total SHDSL8	1	2	3
SHDSL8 Card Watts	14	28	42
LSMT3 Watts	22	22	22
Fan Tray Watts	6	6	6
TOTAL WATTS	**42**	**56**	**70**

SHDSL8

Total DS1	1	2	3
DS1 Card Watts	11	22	33
LSMT3 Watts	22	22	22
Fan Tray Watts	6	6	6
TOTAL WATTS	**39**	**50**	**61**

DS1

Equipment Configurations

There are many possible configurations of the D50 multiplexer, depending on the combination of options selected. One option is data plus voice. If data plus voice is offered, the Low Pass Filter Shelf (LPFS) must be installed between the Main Distribution Frame (MDF) and the Line Card Shelf (LCS). The LPFS can be co-located with the LCS:
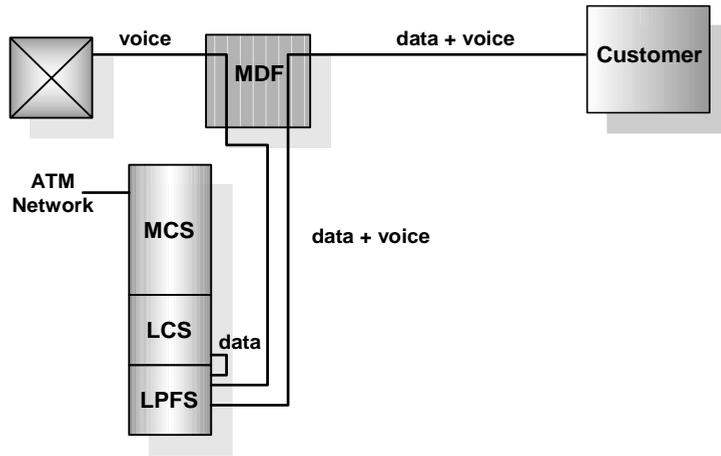
Figure 2-5: LPFS Co-located with LCS

The LPFS can be co-located with the MDF:
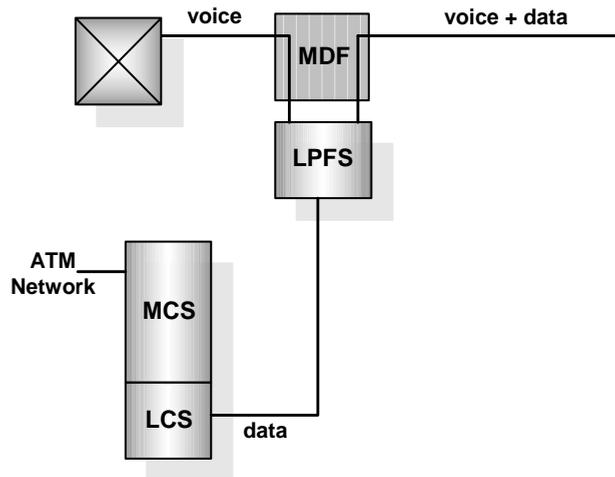
Figure 2-6: LPFS Co-located with MDF

The LPFS can be located independently of the MDF and LCS:
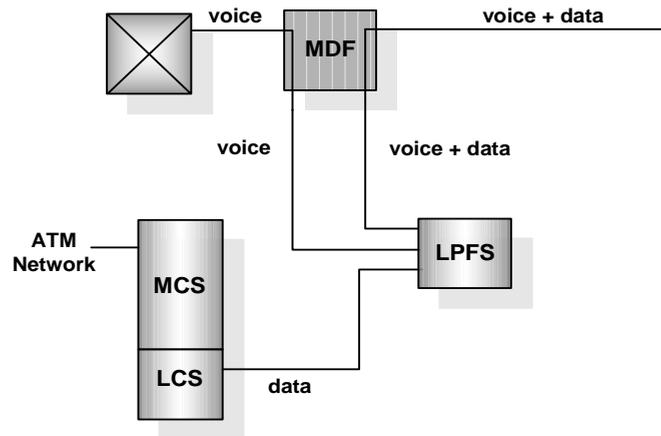
Figure 2-7: LPFS Located Independently from the MDF and LCS

Note: Lengths of cables between the MDF and the LPFS, and also between the LPFS and the LCS, can affect both voice and data performance and should be minimized whenever possible. In no case should the LPFS be located more than 655 feet from the LCS.

Some telecommunications service providers may decide not to offer data plus voice. In this case the LPFS is unnecessary, because there is no voice signal carried by the loop. The D50 multiplexer then consists of an MCS, one or more LCSs, and one or more D50 RAMs.

It is also valid to configure a D50 multiplexer with some LCSs supporting data plus voice connections, and others supporting data only connections. Such a system would have LPFSs for the LCSs supporting data plus voice, but not for the LCSs supporting data only.

Another set of choices involves where to locate an LCS. An LCS may be at a remote location, such as a Controlled Environmental Vault (CEV) or hut. The remote LCS supports loops that do not conform to the Revised Resistance Design rules or contain load coils.

The Remote LCS data only configuration looks like this:
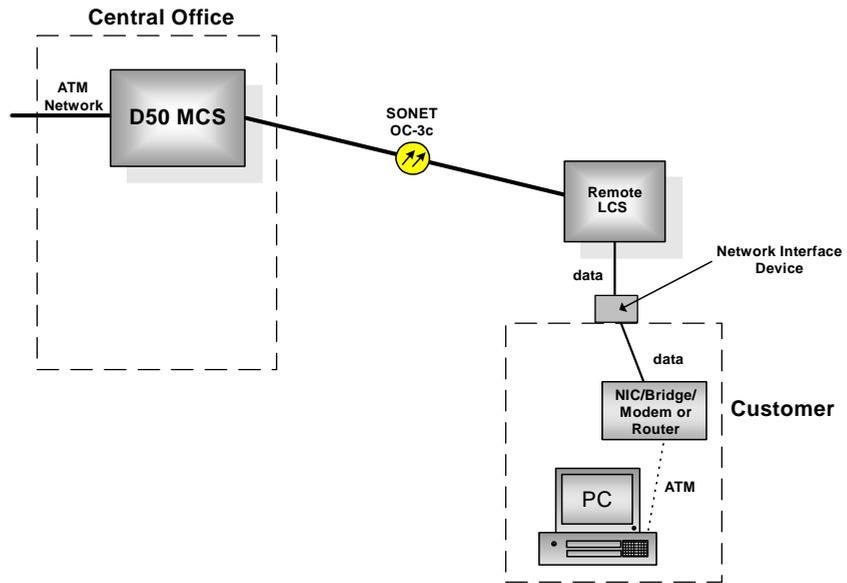
Figure 2-8: Remote LCS Configuration: Data Only

While the configuration shown above is for data only, a data plus voice version is also available using an LPFS:
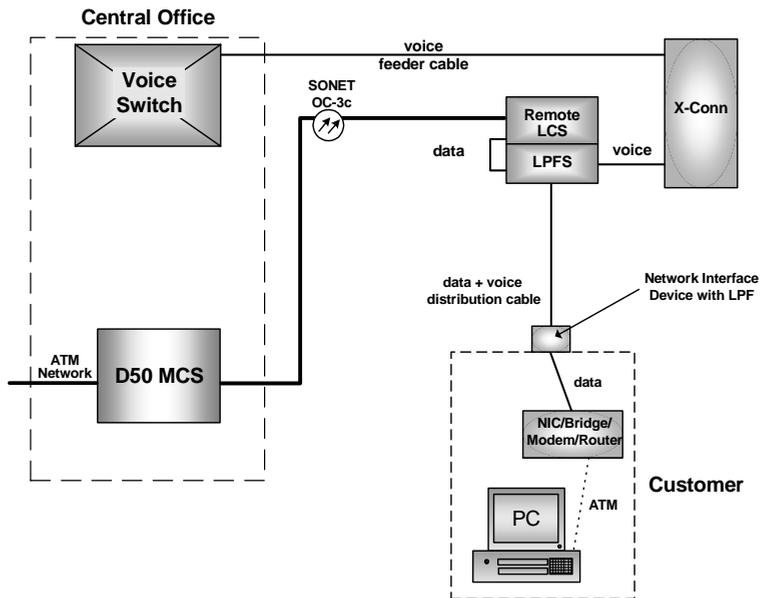
Figure 2-9: Remote LCS Configuration: Data plus Voice

Electrical Protection Requirements

The D50 multiplexer's MDF interface conforms to GR-1089, protecting the multiplexer from 1st level lightning protection (1500V maximum). The multiplexer also conforms to GR-1089 and UL 1459 with respect to power-cross overvoltage (600V AC maximum).

The D50 modem's interface to the PC conforms to GR-1089 and GR-49, protecting the modem from 2nd level lightning protection. The D50's router interface to the twisted pair conforms to FCC Part 68 and UL 1459 electrical protection standards.

Traffic

The D50 guarantees a service category to and from the ATM network for each PVC (Permanent Virtual Circuit). However, if subscriber traffic exceeds the rate[1] of the connection between the LCS (Line Card Shelf) to the MCS (Master Control Shelf) and ATM CAC (Connection, Admission, and Control) is not enabled, the D50 allocates bandwidth through a priority queuing mechanism.
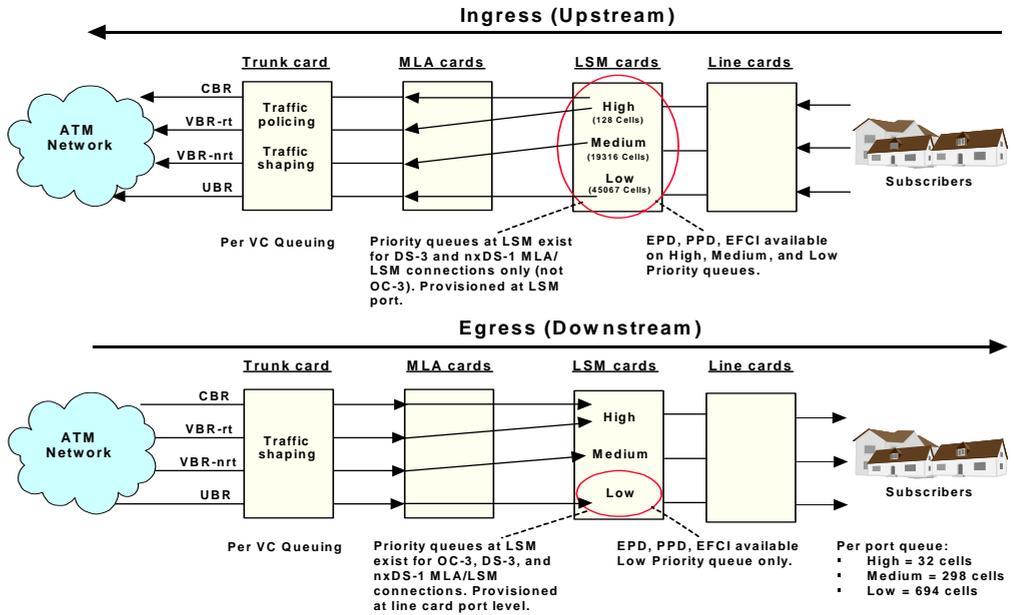
Figure 2-10: ATM QoS Implementation in the D50

ATM CAC. CAC prevents Operators from oversubscribing the D50 with larger bandwidth connections than the system resources can provide (essentially trunking bandwidth). CAC takes connection requests from users, processes the requests, and then outputs decisions to either accept or reject connection requests based on the effective bandwidth of the connection and the currently available bandwidth resources of the D50 system. The statistical nature of the ATM traffic patterns makes it feasible to use oversubscription and gain a high utilization of the D50 resources by turning the CAC OFF. If the Operator wants the bandwidth resources managed automatically then the CAC should be turned ON and the system will manage the bandwidth of all connections provisioned.

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[1] D50 MCS to LCS interfaces include OC-3, DS-3, and 4xDS-1 rates.

■ CAC, if turned ON, will warn user via a Craft Terminal error message, when appropriate, that the connection cannot be provisioned due to the unavailability of system resources to support that connection. CAC is provisionable from Craft Terminal.

■ CAC calculates effective bandwidth and allocation per class, as follows:

$$\frac{BW_{allc} \, (rt\text{-}VBR)}{BW_{eff} \, (rt\text{-}VBR)} = \frac{BW_{allc} \, (nrt\text{-}VBR)}{BW_{eff} \, (nrt\text{-}VBR)} = \frac{BW_{allc} \, (UBR+)}{BW_{eff} \, (UBR+)}$$

Note: BW_{allc} is the bandwidth allocated per class and BW_{eff} is the effective bandwidth per class, with the goal of the CAC being to effectively balance the system resources between the different traffic classes.

■ The default setting for the **Enable ATM CAC** parameter is OFF. The operator must manually manage the oversubscription if CAC is turned OFF.

■ System alarms for CAC "violations" are system configured and cannot be user provisioned.

■ CAC is only effective when connections are being provisioned while normal ATM QoS mechanisms police and shape data in connections so that they remain within their traffic contracts.

Service Categories Mapped to Priority Queues. Each of the service categories is mapped to a different priority queue for bandwidth allocation within the D50:

• CBR and VBR-rt connections are mapped to the *High* priority queue.

• VBR-nrt and UBR+ connections are mapped to the *Medium* priority queue.

• UBR connections are mapped to the *Low* priority queue.

Priority queues are provided in both the upstream and downstream direction.

Traffic Policing. Once a virtual circuit has been established, active processes monitor and enforce the rules embodied in the traffic contract (traffic policing). Traffic policing is carried out by the Usage Parameter Control (UPC) process component, which resides in the D50's DS3TQ and OC3TQ trunk cards. UPC is responsible for ensuring that the traffic submitted to the network does not exceed the performance parameters in the traffic descriptor.

Downstream traffic policing is normally performed as the traffic exits the equipment at the edge of the network boundary. As a result, the ATM switch (edge interface) provides the traffic policing function. Therefore, downstream traffic policing has been disabled on the DS3TQ and OC3TQ trunk cards. However, trunk cards do provide traffic shaping in the downstream direction. The DS3TQ and OC3TQ trunk cards provide both traffic policing and traffic shaping in the upstream direction.

MLAT1/LSMT1 Traffic Management. When high-priority queue traffic in the MLAT1/LSMT1 intra-office or inter-office link passes a user-defined over-utilization threshold for total bandwidth utilization, an alarm will be generated. The alarm is viewable in Craft Terminal, which can be used to monitor, track, and report link utilization levels. Alarms for low and medium priority queue MLAT1 traffic will, as in past releases, report congestion based on user-defined queue buffer depth thresholds.

The MLAT1 utilization alarm indicates when bandwidth on all active ATM PVCs on the IMUX port exceeds the severe level threshold for a set period of time (in seconds). The alarm is cleared when the bandwidth recedes below the abate level threshold for a

set period of time (in seconds). The bandwidth utilization threshold is a percentage of total bandwidth on all MLA/LSM links on the MLAT1 port.

Bandwidth utilization is activated by enabling congestion measurement for the **High** priority queue[2]. The utilization alarm is configurable in both the ingress and egress direction.

Trunk and LSM Queues. At the trunk card, "per VC queuing" is supported – each virtual connection has a separate buffer. The total buffer size is 1536K cells, which includes the upstream and downstream directions together.

In the ingress (upstream) direction, for DS-3 and 4xDS-1 connections only, the LSM cards have queue sizes of 64K cells. The default sizes for the queues are:

- High – 128 cells
- Medium – 19316 cells
- Low – 45067 cells

Note: For OC-3 MLA/LSM connections, there are no priority queues on the LSM cards in the upstream direction.

Low priority connections have the largest queue size because in the event of congestion, High priority connections would be the first to flow through the system, followed by Medium priority, and then Low priority. The Low priority queue size needs to be the largest since these connections will most likely have to wait for sufficient bandwidth to flow through the system.

Note: In the downstream direction, for OC-3, DS-3 and 4xDS-1 MLA/LSM connections, the queue sizes are provisionable at the line card port level but the queues are actually held at the LSM cards.

Selected priority queues on the LSM cards use these congestion control features:

- **Early Packet Discard (EPD)** (also called Frame Discard) – once the queue congestion threshold is reached, EPD stops all new incoming packets (a Protocol Data Unit consisting of ATM cells) and makes an intelligent choice of dropping all cells in a packet instead of randomly dropping cells from many packets.
- **Partial Packet Discard (PPD)** – when an EPD congestion threshold is reached, PPD discards all the remaining cells of the packet that have already entered the queue, until the end of cell (EOC) marked cell is detected.
- **Explicit Forward Congestion Indication (EFCI)** – notifies other network resources that a given queue is in a congestion state.

As noted earlier, OC-3 MLA/LSM interfaces do not have priority queues at the LSM card in the upstream direction. For DS-3 and 4xDS-1 MLA/LSM interfaces, priority queues (High, Medium and Low) are held at the LSM card and EPD, PPD and EFCI are used to manage all three queues.

In the downstream direction, all MLA/LSM interface types (OC-3, DS-3, and 4xDS-1) have queues at the LSM card.

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[2] When the queue priority is set to **Medium** or **Low**, the MLA monitors queue buffer depth instead of bandwidth utilization.

SECTION 3 APPENDICES

Contents

List of Tables

10BaseT. A 10 Mbps Ethernet network that uses unshielded twisted pair cable in a star topology with a central hub.

2B1Q (Two Binary, One Quaternary). A line encoding technique used in ISDN BRI, IDSL and SDSL. It is a four-level PAM (Pulse Amplitude Modulation) technique, which maps two bits of data into one quaternary symbol, with each symbol comprising one of four variations in amplitude and polarity over a circuit.

AAL (ATM Adaptation Layer). ATM Adaptation Layer is located above ATM and converts non-ATM bit streams into ATM cells. The AAL protocol supports higher-layer service requirements.

ADSL (Asymmetric Digital Subscriber Line). Asymmetrical data signals for Internet access that share twisted pairs with POTS and that use modern signal modulation techniques to accomplish the data communications task. The downstream rates are much faster than the upstream rates.

AIS (Alarm Indication Signal). A downstream signal in a digital network that replaces the normal traffic signal when a maintenance alarm indication has been activated (indicating an upstream failure detection − error or alarm on the network). It is used in the OSI network management model.

Alarm. A signal used to indicate that an abnormality, a fault, or a failure has been detected. Alarms may be distinguished by type and by the severity of the event that caused the alarm.

ANSI (American National Standards Institute). Founded in 1918, ANSI is a U.S. voluntary standards setting board.

API (Application Programming Interface). Software that an application program uses to request and carry out lower-level services performed by an operating system.

ASCII (American Standard Code for Information Interchange). A computer coding method for converting alphanumeric and punctuation characters and control codes into digital (binary) form.

ATM (Asynchronous Transfer Mode). A multiplexed information transfer and switching process (cell-switched technology) in which data is organized into fixed length (53 octet) cells and transmitted according to each application's requirement. ATM is generally deployed in enterprise networks, which often connect LANs over wide areas that require large amounts of data to be transported over great distances.

Attenuation. Attenuation is the loss of signal strength over distance. Attenuation is measured in decibels.

ATUC (ADSL Transmission Unit – Central Office). Special electronics located in the Central Office to support a high rate of data transmission over UTP copper wires. This is the "downstream" direction. Works in conjunction with ATUR (see below).

ATUR (ADSL Transmission Unit – Remote). Special electronics located at the customer's premises to support a high rate of data transmission over UTP copper wires. This is the "upstream" direction. Works in conjunction with ATUC (see above).

AutoBaud. A set of drivers available on SDSL devices to promote inter-operability.

Auxiliary Common Systems Interface Panel (CSIP). Each Auxiliary CSIP connects and distributes Central Office power to up to four Line Card Shelves (LCSs). Auxiliary CSIPs are required for D50's with over five LCSs.

AWG (American Wire Gauge). A standard classification for measuring non-ferrous conductors such as copper wire.

Backbone. The part of a network that carries the heaviest traffic. It is one basis for the design of an overall network service. For example, the D50 operates on an ATM backbone.

Bandwidth. The capacity of a communications channel. For digital communications, bandwidth is usually measured in bits per second.

BER (Bit Error Rate). A measurement of transmission quality expressed as a ratio (ratio of error bits to the total number of bits transmitted – erroneous bits per million). The BER indicates how many bits are incorrectly transmitted in a given bit stream. The BER depends on the type and length of transmission.

BNC (Bayonett Neill Concelman). A bayonet-locking cabling interconnection standard, used in thin coaxial cable Ethernet applications.

BPS (Bits Per Second). A measurement of transmission speed – number of bits transmitted each second.

Bridge. A communications device used to interconnect networks or network nodes with a common set of higher level protocols.

Broadband. A communications method in which multiple channels are formed by dividing the transmission medium on a shared communications path. Generally describes communications above 1.5 Mbps.

Burst. A short flow of packets, often followed by idle periods where there is no transmission activity.

CAC (Connection Admission Control). Procedures carried out by an ATM network at connection set-up to determine whether a requested virtual connection can be supported or should be rejected.

CAM (Complimentary Analysis Module). A Nokia Broadband Systems product. A card that is used to provide the pathway to perform continuity testing from the LCS to the MDF when using a Low Pass Filter Shelf (LPFS8). Plugs into the LPFS8 backplane in the same manner as a Low Pass Filter card. Works with the PAM (Pair Analysis Module) card.

CAP (Competitive Access Provider). An alternative competitive local exchange carrier.

CBR (Constant or Continuous Bit Rate). An ATM service category that supports a constant or guaranteed rate to transport services such as video or voice as well as circuit emulation requiring rigorous timing control and performance parameters.

CCA (Congestion Control and Avoidance). A resource and traffic management mechanism to correct, avoid and/or prevent excessive situations such as buffer overflow or insufficient bandwidth that can cause the network to collapse.

CDV (Cell Delay Variance). A component of Cell Transfer Delay, induced by buffering and scheduling.

CDVT (Cell Delay Variance Tolerance). Specifies the acceptable tolerance to cell-by-cell variations of the CDV (jitter).

CE. Products sold into the European Economic Community since January 1996 are required to carry the CE Mark. The CE Mark represents that the product meets all Electromagnetic Compatibility Directives.

Cell. The smallest data component in an ATM stream. The ATM Cell has a 5-byte header and contains 48 bytes of payload.

CEV (Controlled Environment Vault). An environmentally conditioned room for housing optical and electronic equipment.

Channel. A point-to-point link in a communications system.

Circuit. A transmission path for sending and receiving data and/or voice between two points in a telecommunications system.

Circuit Emulation. A virtual circuit service offered to end users where the characteristics of an actual, digital bit-stream line (for example, video traffic) are emulated.

CLEC (Competitive Local Exchange Carrier). These carriers compete with the local exchange service to provide telephone service to customers who may choose voice and/or data services. Additionally, a CLEC may lease existing lines or provide their own local loop.

CLEI (Common Language Equipment Identifier) Codes. Assigned to all telecommunications equipment that may be installed in a RBOC facility (or other facilities if required). The codes are assigned by Bellcore (now SAIC).

Client/Server Model. In the client-server model, the *server* program offers a service reachable over the network (or within a stand-alone system). A server receives a request, performs the service, and returns the result to the requester. The *client* program sends a request to the server and waits for a response.

CLP (Cell Loss Priority). A 1-bit field in the ATM cell header that corresponds to the loss priority of a cell. Lower priority (CLP=1) cells can be discarded under a congestion situation.

CLR (Cell Loss Ratio). A QoS parameter that gives the ratio of the lost cells to the total number of transmitted cells on a given VCC in cells per second.

CMIP (Common Management Information Protocol). An OSI network management/service interface protocol created and standardized by ISO. Based on the basic data storage concept in which management information is collected and stored for subsequent retrieval by a management application. Provides for the transmission of event notifications and the transmission of operations directed toward managed objects.

CO (Central Office). Houses the Local Exchange switch that terminates individual local telephone subscriber lines for switching and connection to the public network (locally and long distance).

Coding Violation (CV). A violation detected in the coding of a signal.

Common Systems Interface Panel (CSIP) Alarm Board. All D50 alarm connections are made at the CSIP Alarm Board; Central Office visual, audible, remote Bay Alarm and remote input alarms. The Alarm Board has LEDs to display D50 alarm status.

Common Systems Interface Panel (CSIP) Power and Distribution Board. The CSIP Power and Distribution Board is located in the Master Control Shelf (MCS). Central Office power is terminated at the CSIP and is distributed to the MCS and up to four Line Card Shelves (LCSs).

CORBA (Common Object Resource Broker Architecture). An Object Request Broker (ORB) standard developed by the Object Management Group (OMG). It is an object-oriented technology which provides a scalable, open platform for both service provider and large enterprise network environments.

COT (Central Office Terminal or Termination). The termination of a local loop facility. Located at the Central Office facility. See Digital Loop Carrier for further information about how this is used.

CPE (Customer Premises Equipment). Refers to telephone and related equipment located on the customer's premises (office or home).

Craft Terminal (DiamondCraft®). Craft Terminal, previously known as DiamondCraft, is the D50's stand-alone craft interface application. It communicates directly with a D50 through a serial port connection using Point-to Point Protocol (PPP) or an Ethernet connection.

CRC (Cyclical Redundancy Checking). A data error-detecting mathematical process designed to ensure that errors don't occur undetected in a block of data. Systems using CRC will request that data be retransmitted if errors are detected.

Cross-connect. A connection between two or more elements of a telecommunications system.

CTD (Cell Transfer Delay). A QoS parameter that measures the maximum or worst-case time for a cell to be transferred from its source to its destination over a virtual connection. It is the sum of buffering, propagation, processing and queuing delays.

D50 RAM (Remote Access Module). The D50 RAM is a small, versatile DSL remote line card shelf supporting up to three 8-port D50 line cards, one Line Control Shelf

Multiplexer card, and three low pass filter cards, for up to 24 lines. It is equivalent to a small LCS.

D50 Multiplexer. The D50 Multiplexer is classified as a Digital Subscriber Line Access Multiplexer (DSLAM). The D50 Multiplexer uses Digital Subscriber Line (DSL) and Asynchronous Transfer Mode (ATM) technologies to deliver high speed data rates over the existing copper network.

Data Rate. The rate at which a channel carries data – measured in bits per second.

dB (Decibel). The decibel is a unit used to measure the power of sound or voltage. It is expressed as the ratio of two values. In telephony, the decibel (a logarithmic measurement) is used as a measure of relative power between circuits or transmission level points. As a reference: a change in level of 1 dB is barely perceptible under ideal conditions; however, increases or reductions of 3 dB result in doubling or halving, respectively, the power in a circuit. The corresponding figure for doubling or halving voltage is 6 dB.

DLC (Digital Loop Carrier). Network transmission equipment used to provide a pair gain function. DLC equipment is deployed in situations in which the cost of the equipment is more than offset by the savings in copper distribution accomplished by eliminating need for as many copper pairs. Digital loop carrier systems consist of two parts—a Central Office Terminal (COT) and a Remote Terminal. The COT provides the multiplexing/demultiplexing function of individual voice signals to the composite multiplexed signal at the interface between the switching equipment and the DLC. The Remote Terminal provides the multiplexing/demultiplexing function at the interface between the individual subscriber pairs and the DLC equipment.

DMT (Discrete Multi-Tone). Modulation technique which uses Frequency Division Duplex multiplexing to transmit data in the 35 kHz to 1.1 MHz frequency spectrum. It divides the frequency range into 256 discrete bands, each with 4 kHz bandwidth. Each band is independently modulated.

Downstream. The communications path going <u>from</u> the CO or DSLAM <u>to</u> the client/end user.

DS1 (Digital Signal Level One). 1.544 Mbps digital signal.

DS3 (Digital Signal Level Three). 44.736 Mbps digital signal − equivalent of 28 T-1 channels (also referred to as T-3).

DS3L. A DS3 rate broadband tributary card that provides a standard ATM UNI/NNI interface that supports provisionable VPI/VCI mappings to the D50 trunk card, allowing ATM cells to be aggregated from standard ATM network equipment.

DSL (Digital Subscriber Line). The generic name for a family of digital services provided by the local telephone companies to their local subscribers. The high speeds of transmission (up to 8 Mbps) are accomplished over the existing twisted pair copper wires.

DSLAM (Digital Subscriber Line Access Multiplexer). An ATM access mux/concentrator that grooms traffic from multiple low rate lines into a high rate trunk (DS1, DS3, OC3, OC12).

Duplex. Simultaneous, two-way independent transmission of data. Both ends of the communication can send and receive data at the same time. Also referred to as full-duplex.

EFCI (Explicit Forward Congestion Indication). A field in the ATM cell header indicating congestion or impending congestion. When EFCI is set, it indicates that a network element is either in a congested state or there is a potential congested state problem. The ATM end-system receiving cells with EFCI set can use this indication to adaptively decrease the cell rate of the connection to avoid congestion.

Egress. Outgoing direction to a network or network device. The term refers to data being sent out of a device or system, as opposed to information being sent into a network or network device (ingress).

EMI (Electromagnetic Interference). Unwanted electrical noise from an external source that can interfere with transmissions over copper cables.

EML (Element Management Layer). A layer representing the management and monitoring of components, at their lowest level, in a telecommunications network. In short, an abstraction of the functions provided by systems that manage each network element on an individual basis.

EMS (Element Management Systems). Software used to manage and monitor components of a telecommunication system at the lower levels of the Telecommunications Management Network.

EOC (Embedded Operations Channel). A control and signaling channel used for operations, administration and maintenance of the transmission line.

EPD (Early Packet Discard). A congestion control technique that selectively drops all but the last ATM cell in a Classical IP over ATM packet.

Error Rate. The ratio of incorrect elements sent to the total number of elements transmitted.

ES (Errored Seconds). The number of seconds in which at least one coding violation was detected.

ESD (Electrostatic Discharge). Transfer of an electrostatic charge on a surface through a conductive path to ground.

ETSI (European Telecommunications Standards Institute). ETSI is the European counterpart to ANSI, the American National Standards Institute. ETSI was founded in 1988.

Fault. Performance degradation that impacts the ability of the network element from properly performing.

FEBE (Far End Block Error). FEBE is used to monitor bit error performance of a communication link. An indication returned to the source that the far-end receiver has detected one or more errors in its received signal from the source.

FEC (Forward Error Correction). A transmission method in which extra bits or characters transmitted with the payload so that transmission errors can be corrected on the receiving end without forcing a retransmission.

FM (Fault Management). A data collection and reporting mechanism for component fault analysis.

Frame. In Time Division Multiplexing (TDM), a frame is one complete cycle of events. The frame consists of a fixed-size block of bits, which contains one (or more) time slots for each channel, plus synchronization and other overhead bits.

Frame Relay. Frame Relay is a packet mode switching interface defined by the ITU-T. Frame relay is provided on fractional T-1 or full T-carrier system carriers.

FRF. Frame Relay Forum.

FRF.5. Frame Relay/ATM PVC Network Interworking Implementation Agreement. FRF.5 provides the standard for ATM to become a high speed backbone for Frame Relay PVCs.

FRF.8. Frame Relay/ATM PVC Network Interworking Implementation Agreement. FRF.8 provides the standard for Frame Relay PVCs and ATM PVCs to communicate.

GFC (Generic Flow Control). A four bit field in the ATM header which can be used to provide local functions (e.g. flow control). The GFC is used to ensure that all nodes obtain access to the transmission medium. It can also be used to prioritize transmissions by data type.

GUI (Graphical User Interface). Generic name for the computer interface that presents graphics (icons) and characters. The GUI permits users to directly manipulate graphical objects displayed on the monitor.

HDLC (High Level Data Link Control). An ITU-TSS link layer protocol standard for point-to-point and multi-point communications. HDLC includes functions for link establishment, sequencing, flow control and error recovery.

HDSL (High bit rate Digital Subscriber Line). HDSL provides a T1 on two copper wire pairs (without the loop engineering and repeaters required for a standard T1 system).

HEC (Header Error Control). An 8-bit field (the last byte) of the ATM-cell header, whose purpose is to allow a receiver to detect, and possibly correct, transmission errors in the cell header. It is used for checking integrity only.

HTML (Hyper Text Markup Language). HTML is the software programming language used to create World Wide Web pages.

IAD (Integrated Access Device). An integrated-access device that can multiplex voice and data on one line.

IDF (Intermediate Distribution Frame). A metal rack designed to connect cables and located in an equipment room or closet. Consists of bits and pieces that provide the connection between inter-building cabling and the intra-building cabling (i.e. between the Main Distribution Frame (MDF) and individual phone wiring).

IDSL (ISDN Digital Subscriber Line). Delivers speeds up to 128/144 Kbps on copper loops as long as 18,000 feet. Dedicated service for data communications applications only. 2B1Q interface. In most cases, users can use their existing ISDN CPE equipment.

IEEE (Institute of Electrical and Electronics Engineers). An international engineering organization that defines standards related to networking and other areas.

IETF (Internet Engineering Task Force). One of two technical engineering bodies of the Internet Architecture Board. The IETF is responsible for solving short-term engineering needs and standards of the Internet.

ILEC (Incumbent Local Exchange Carrier). The local carrier that is (typically) the primary carrier for local calls in a given area. ILECs are telephone companies that were part of the Bell System.

In-Band. Using the same circuit to transport both the information (e.g., data or voice) along with the signaling information.

Ingress. Incoming direction to a network or network device. The term refers to data being sent into a network element or system, as opposed to information being sent out (egress).

Interleave. A process or technique that reduces the number of undetected error bursts and improves burst error performance. Interleave mode provides the most robust service and more reliable service under long reach conditions for DSL service that supports the Interleave process.

Inverse Multiplexer (IMUX). A device that combines multiple links (usually T1s or E1s) a single shared digital channel. Circuits can be added and dropped without losing ATM cells.

IP (Internet Protocol). A component of the TCP/IP protocol suite. IP operates at Layer 3 of the OSI Reference model.

ISDN (Integrated Services Digital Network). ISDN is a digital telecommunications standard for transmitting digital voice, data and video on the same transmission facility. ISDN has two basic access interfaces; BRI (Basic Rate Interface) and PRI (Primary Rate Interface). Both interfaces provide circuit-switched access to public networks. BRI provides a throughput of 144 Kbps and PRI has a throughput of up to 2 Mbps.

ISO (International Standards Organization). The International Standards Organization is an international organization founded in 1946 to facilitate the development of international data communication standards.

ISP (Internet Service Provider). A vendor who provides access to the Internet and the World Wide Web.

ISU (Integrated Services Unit). A digital device that consists of a CSU (Channel Service Unit) and DSU (Digital Service Unit).

ITU (International Telecommunications Union). An organization established by the United Nations. The ITU sets telecommunications standards and allocates frequencies to various uses worldwide.

IWF (Interworking Function). A function used on an interface between networks which use dissimilar technologies.

IXC (Interexchange Carrier). Long distance carrier such as AT&T, MCI WorldCom, Sprint, and some smaller carriers.

Java. A programming language developed by Sun Microsystems® for platform independent, object-oriented application development.

JDBC (Java DataBase Connectivity). A Java based driver which provides a database independent interface between a Java application or applet and the database. It provides a Java API on one side and an SQL interface on the other.

JDK (Java Developer's Kit). A (platform specific) development environment for creating Java based applications and applets.

Kbps (Kilo Bits Per Second). A measurement of transmission speed – one thousand bits transmitted each second.

kHz (Kilohertz). A unit of frequency equal to one thousand (1,000) cycles per second (Hz).

LAN (Local Area Network). A privately owned and administered network for data communications, usually within a building or campus environment, used to connect computers and peripheral devices. Communication is typically accomplished by broadcasting on a connectionless basis over a shared medium.

Latency. The amount of time between the moment a device generates a request for data and the instant at which the requested channel is available for transmission.

Leaky Bucket Algorithm. Officially called the Generic Cell Rate Algorithm. A method of explaining by means of a hole in a bucket, how an ATM switch measures the PCR and SCR conformance of each CBR and VBR connection.

Line Card. A line card serves as the interface between a line and a communications device.

Line Card Shelf (LCS). The D50 is made up of one Master Control Shelf and up to twelve Line Card Shelves. Each LCS has 24 mounting slots for line cards, one slot for a Line Card Shelf Multiplexer (LSM) card, and one slot for an optional LSM card for Remote Line Card Shelf protection group application.

Line Card Shelf Multiplexer (LSM) card. The LSM card communicates with the Master Line Card Adapter (MLA) card. The LSM multiplexes and demultiplexes ATM cell streams for up to 24 line cards in a Line Card Shelf.

Link A. The virtual connection path between the D50 and the CPE (or line card) side of the network.

Link Z. The virtual connection path between the D50 and the ATM side of the network.

LISP (Local Internet Service Provider). See ISP (Internet Service Provider).

Local Loop. The twisted pair cable connecting the subscriber to the Central Office.

LOF (Loss of Frame). A condition that can occur in digital transmissions when the receiving equipment loses frame alignment data (used to determine channel assignments and channel boundaries).

Loopback. Type of diagnostic test in which the transmitted signal is returned to the sending device after passing through a data communications link or network. The returned signal is then evaluated (either by a technician or diagnostic equipment) to get some sense of the condition of the line. Typically used in troubleshooting a data circuit or network.

LOS (Loss of Signal). An alarm sent by the receiving end to indicate that the transmission signal has been lost.

Low Pass Filter Shelf (LPFS8). Data plus voice frequency signals are received from the customer at the Low Pass Filter Shelf. The LPF8 card "splits" the low frequency voice signal from the high frequency ADSL signal. The voice signal is sent to the voice switch unimpeded; the data signal is received by the line card.

Master Control Processor (MCP) card. The MCP card is the central control and communications path for the D50; it stores program and provisioning database information. The D50 has two MCP cards in a 1:1 protection group.

Master Control Shelf (MCS). The MCS contains the central control and communication functions for the D50 and serves as the ATM network interface.

Master Line Card Adapter (MLA) card. Each MLA card provides the broadband interface to one Line Card Shelf. There are up to twelve MLA cards in a Master Control Shelf providing the broadband interface for up to twelve Line Card Shelves and up to 288 line cards.

Mbps (Mega Bits Per Second). A measurement of transmission speed – one million bits transmitted each second.

MBS (Maximum Burst Size). An ATM traffic parameter that specifies the maximum number of cells in a burst that can be transmitted at the peak rate assuming that, at the beginning of the burst, the receiving buffers are empty.

MDF (Main Distribution Frame). A wiring arrangement which connects the telephone/data lines coming from outside on one side and the internal lines on the other.

MDU (Multiple Dwelling Unit). Refers to high-rise apartment buildings or sometimes office buildings. Newer MDUs are often being built with fiber optic cables and other equipment (such as DSLAMs) installed so the occupants have easy access to high-speed data services.

MHz (Megahertz). A unit of frequency equal to one million (1,000,000) cycles per second (Hz).

MIB (Management Information Base). The MIB contains all the provisioning information for the D50 Multiplexer. (The MIB contains data available to a network management program. The network manager queries the MIB.)

MTBF (Mean Time Between Failure). Reliability metric for electronic equipment that represents the average amount of time (expected or predicted) between breakdowns.

Multi-mode Fiber. Fiber whose core diameter is larger than single mode fiber, which allows many modes of light to propagate down the multiple fiber optic paths. Each of these paths has a slightly different length, depending upon how often the light

bounces off the reflective boundary of the core region. Multi-mode fiber is used for short-distance data links.

Multiplexer. Equipment that aggregates two or more channels onto a single transmission channel.

MUX. Abbreviation for Multiplexer.

NE (Network Element). Processor controlled entities of the telecommunications network that primarily provide switching and transport network functions and contain network operations functions.

NEBS (Network Equipment Building System). NEBS is the Network Equipment Building System specification authored by Bellcore. NEBS compliance is required by many carrier customers; the D50 shipping today is already NEBS-compliant.

Network Management Processor (NMP) card. The NMP card controls the D50's network management interfaces and provides the protocol support for communication for D50 Craft Terminal.

NIC (Network Interface Card). An electronic circuitry board that usually fits into an expansion slot of a PC whose purpose is to connect to a Local Area Network. A NIC is designed to comply with both a specific LAN Medium Access Control procedure (CSMA/CD for Ethernet) and a specific physical medium (e.g. twisted pair wire, coax, or multi-mode fiber). Associated with the NIC is a unique address called the MAC address. It works with the network software and computer operating system to transmit and receive messages on the network.

NID (Network Interface Device). The Nokia Broadband Systems' NID ADSL Splitter divides the ADSL and POTS signals and works in conjunction with the router at the subscriber end. The splitter installs on the outside of a home or building, and is enclosed in a weatherproof wall mount enclosure. It features primary lighting and AC power fault protection, and is a passive device, requiring no power or management from the Central Office or subscriber.

NISP (National Internet Service Provider). See ISP (Internet Service Provider).

NNI (Network Node Interface). An Asynchronous Transfer Mode (ATM) interface between two public network pieces of equipment (contrast that to UNI, which stands for User Network Interface).

Node. Connection point in a network.

Noise. Unwanted electronic signals or disturbance that degrades line performance.

OAM (Operations And Maintenance). A group of network management functions that provide network fault indication, performance information, and data diagnosis functions.

OC-1 (Optical Carrier Level-1). A SONET line rate of 51.840 Mbps. Direct electrical-to-optical mapping of the STS signal with frame synchronous scrambling.

OC-12. SONET channel of 622.08 Mbps.

OC-3 (Optical Carrier Level-3). A SONET line rate of 155.520 Mbps. 3 x OC-1. Direct electrical-to-optical mapping of the STS signal with frame synchronous scrambling.

OC3L. A OC3 rate broadband tributary card that provides a standard ATM UNI/NNI interface that supports provisionable VPI/VCI mappings to the D50 trunk card, allowing ATM cells to be aggregated from standard ATM network equipment.

ODF (Optical Distribution Frame). Connection and distribution point for fiber optic cables. It is similar, in function, to an MDF for copper wires.

Optical Cross-Connect Panel. A cross-connect unit used for circuit administration and built from modular cabinets. It provides for the connection of individual optical fibers with optical fiber patch cords.

Oracle8®. An Object Relational Database Management System developed by Oracle.

ORB (Object Request Broker). An object-oriented system consisting of middleware which manages message traffic between application software and computer/software platforms.

OSI (Open System Interconnection Reference Model). An internationally accepted set of standards for communication between various systems manufactured by different vendors. The OSI Reference Model is a seven-layer model developed by the ISO (International Standardization Organization) to describe how to connect any combination of devices to communicate.

OSS (Operations Support System). A management operations center system which supports the daily operation of a telecommunications network.

Packet. A block or group of data organized in such a way as to be treated as a single unit within a communication network. It consists of the data (payload) and its control information.

Pair Bonding. This SHDSL feature enables the user to bond 2 ports to effectively double the maximum single-port bandwidth of 2.3 Mbps to provide up to 4.6 Mbps of symmetrical service.

PAM (Pair Analysis Module) card. A Nokia Broadband Systems' product. The PAM card plugs into the LCS backplane just like a line card and is used to test continuity of cable pair wiring from the LCS to the MDF. The PAM card is powered by AA batteries or -48V Central Office battery. The D50 does not have to be powered up to use the PAM card.

Payload. The data being transmitted, less its control and error-correction information.

PCI (Peripheral Component Interconnect). Bus of an Intel PC. PCI transfers data between the PC's main microprocessor and peripherals at up to 132 Mbps.

PCR (Peak Cell Rate). Specifies an upper bound on the rate at which traffic can be submitted to an ATM connection. Enforcement of this bound allows the network to allocate sufficient resources to ensure that the network performance objectives can be achieved.

PDF (Portable Document Format). File format of documents that can be viewed with Adobe Acrobat® Reader. PDF files are widely used to view files on the Internet.

PDU (Protocol Data Unit). In data communication protocols, a unit of data created by a given protocol layer at one place and logically transferred to the same layer at another place called a peer. This is the OSI terminology for "packet."

PLCP (Physical Layer Convergence Protocol). The part of the physical layer that adapts the transmission facility to handle DQDB (Distributed Queue Dual Bus) functions as defined in IEEE 802.6-1990.

PM (Performance Monitoring). A data collection and reporting mechanism for Quality of Service analysis.

PNNI (Private Network-to-Network Interface). PNNI is a standard of the ATM Forum that provides a multilevel hierarchical routing model for scalability in large and complex networks using ATM switches from multiple vendors.

POP (Point-of-Presence). The physical place within a LATA (Local Access and Transport Area; the long distance carrier's local office) where the IEC (Inter-Exchange Carrier) provides services to the LEC (Local Exchange Carrier), and perhaps directly to end-users.

POTS (Plain Old Telephone Service). A term used to describe analog, voice-only basic telephone service. All POTS lines work on loop start signaling.

PPP (Point-to-Point Protocol). A layer 2 protocol (relative to the OSI reference model) that allows a computer to use TCP/IP with a standard telephone line and a high-speed modem.

Profile. A set of pre-defined configuration variables which can be applied to one or more objects (of the same type) during the provisioning process. The use of profiles decreases configuration time and increases accuracy.

PSD (Power Spectral Density). PSD is the total power in the specified bandwidth divided by the specified bandwidth. PSD is measured in watts per hertz.

PSTN (Public Switched Telephone Network). Refers to the worldwide telephone system accessible to anyone with a telephone.

PTT (Post Telephone & Telegraph administration). The PTTs, usually controlled by their governments, provide telephone and telecommunications services in most countries outside of the USA.

PVC (Permanent Virtual Circuit). A permanent association between two DTEs (Data Terminal Equipment) established by configuration (established administratively via a service order process). A PVC uses a fixed logical channel to maintain a connection between the DTEs. After a PVC is defined, it requires no setup operation before data is sent and no disconnect operation after. The concept of a PVC is included in Networks supporting X.25, Frame Relay and ATM.

QoS (Quality of Service). In ATM networks, a set of parameters for describing a transmission. These parameters include values such as allowable cell loss ratio. The parameters apply to virtual channel connections and virtual path connections.

RADSL (Rate Adaptive Digital Subscriber Line). Transmission technology that supports both asymmetric and symmetric applications on a single twisted pair telephone line. Transmission rates are dynamically adjusted as the performance of the loop varies during a session.

RBOC (Regional Bell Operating Company). These are the major local service providers in the USA today. In 1984 ATT was broken up into 7 RBOCs. Today,

because of mergers, there are 4 RBOCs: BellSouth, Bell Atlantic, SBC Communications, and US WEST (recently merged with Qwest Communications).

Redundancy. This refers to various designs that provide a backup system (or part of a system) in case of a failure. As an example, the D50 has redundant power input terminals so that if one power source fails the backup source can continue to provide power to the system.

Reed-Solomon. A coding technique used to handle Forward Error Correction (FEC).

Remote Line Card Shelf (RLCS). An RLCS allows customers served over long loops — beyond 5.5 kilometers from the Central Office — access to DSL service. The RLCS is located remotely from the Central Office in an outside cabinet and connected to the Central Office Master Control Shelf via fiber optic, coax or copper cable extensions.

Remote Low Pass Filter (RLPF). The RLPF is a remote passive low pass filter "splitter" device. It splits the high frequency ADSL data signal from the voice signal at the customer end just like the Low Pass Filter card in the Central Office. There are two types of RLPF − a retrofit RLPF available in a standard Network Interface Device housing and a stand-alone RLPF.

RFC (Request for Comments). In the Internet community, a series of documents that contain protocol and model descriptions, experimental results, and reviews. All Internet standard protocols are written up as RFCs.

SCR (Sustainable Cell Rate). An ATM traffic parameter in cells per second that characterizes a bursty source and specifies a maximum average rate at which cells can be sent over a given ATM virtual connection.

SDH (Synchronous Digital Hierarchy). SDH is a high-speed, fiber-optic system, which provides an interface and mechanism for optical transmission of digital information. At the interface, signals are converted from electrical to optical form (and back to electrical form at the destination). SDH is an ETSI standard and is used in most of the world outside North America, where SONET is used. Transmission rates range from 155.520 Mbps to 9.953 Gbps.

SDSL (Symmetric Digital Subscriber Line). Also referred to as Single-Line Digital Subscriber Line, SDSL supports symmetrical T1 transmissions. It uses a single copper-pair wire and has a maximum operating range of 10,000 feet. It is capable of accommodating applications that require identical downstream and upstream speeds, such as video conferencing.

Serial Port. A hardware input/output port in which only one pin is available for data transmission in a given direction − bits are transmitted in sequence (one bit at a time). The wiring for a port is associated with a particular physical interface (i.e., RS-232). A serial port is most commonly used for a modem or a mouse.

Service Provider. A service provider is an organization or individual that provides telephone access to a network or to another service, such as the Internet.

SHDSL (Single line high bit rate DSL). Nokia octal line card supporting 8 ports of symmetric bit-rate transmission using multi-level Trellis Coded Pulse Amplitude Modulation (TC PAM).

Simplex. Simplex communication means that data can only be sent in one direction at a time. Also referred to as half-duplex.

Single Mode Fiber. Single mode fiber only provides one path for light pulses to travel through the fiber optic cable. There is very little loss of light pulses transmitted on single mode fiber. Therefore single mode fiber can be used for much longer distances than multi-mode fiber.

Smart Jack. According to the Newton's Telecom Dictionary, a "Smart Jack" is an industry term for a device that tests the integrity of T-1 circuits remotely from the central office. Installed on the customer premises in the form of a semi-intelligent demarcation point, a Smart Jack is completely passive until activated by code.

SNMP (Simple Network Management Protocol). The network management protocol used within TCP/IP-based internets. Defines the protocol for managers (clients) to communicate with agents (servers). The agent interfaces directly with the networking layers on the monitored network device to obtain the network management information. An agent is installed on every network device that will be managed or monitored. A client is an application program that is installed at the network operations center. It communicates with the SNMP agents to collect information in the form of MIB variables. SNMP is a request/reply protocol that uses the operations of Set or Get on data items in an agent's MIB.

SNR (Signal-to-Noise Ratio). In transmission, SNR is the ratio between the signal and noise levels at a given point, usually at the receiving end of the transmission. The SNR value is generally expressed in decibels (dB). The SNR can be used to determine how long a cable segment can be before the signal loss is unacceptably high. The SNR also helps determine whether a particular type of cable is appropriate for the intended use.

SONET (Synchronous Optical NETwork). SONET is a high-speed, fiber-optic system, which provides an interface and mechanism for optical transmission of digital information. At the interface, signals are converted from electrical to optical form (and back to electrical form at the destination). SONET is an ANSI standard. Transmission rates range from 51.84 Mbps to 13.22 Gbps.

Splitter. A device used in DSL to split the incoming bit stream into voice and data.

Subnet. A physically independent network segment. A subnet usually identifies all of the nodes in one geographical area or building. Nodes on a subnet can share a single network address.

SVC (Switched Virtual Circuit). A virtual connection set up on demand via a signal protocol connection, established for a specific communications session and then terminated after the session is over. This is in contrast to a permanent virtual circuit (PVC), which is a connection that is always established.

T1. DS1 rate electrical signal (two pair). T1 is suited for voice, data and image transmissions. T1 has a bandwidth of 1.544 Mbps, which comes from two dozen 64 Kbps channels, together with one 8 Kbps framing channel.

Tagging. The marking of a non-conforming cell that can be later discarded along its route through the ATM network if severe congestion conditions are experienced or the cell is still in violation of the traffic contract.

TCM (Trellis Coding Modulation). A method of forward error correction in which each signal element is assigned a value based on phase and amplitude to help the receiving modem determine if the element is received in error. Allows the user to meet performance margin requirements for long loops, or increase the transmission throughput under a specified performance margin; provides increased gain against background and crosstalk noise.

TCP/IP (Transmission Control Protocol / Internet Protocol). TCP/IP is a common suite of several networking protocols developed for use on the Internet.

Telnet. Telnet is the terminal-remote host protocol developed for ARPAnet in 1974. On the Internet, it is a service program that allows you to connect to other computers at another site permitting you to interact with applications as if by a local terminal.

Threshold. Level or value of a particular signal where an event or alarm will be generated.

TMN (Telecommunications Management Network). Reference model for telecommunications network management.

Transmission rates. The speed at which data is transmitted, measured in bits per second (bps).

Table 3-1: Transmission Rates

DS level	E level	OC level	STM equivalents	Line bit rate
DS-0				64 Kbps
DS-1 (T-1)				1.544 Mbps
	E-1			2.048 Mbps
DS-2				6.312 Mbps
	E-2			8.448 Mbps
	E-3			34.368 Mbps
DS-3 (T-3)				44.736 Mbps
		OC-1		51.840 Mbps
		OC-3	STM-1	155.52 Mbps
		OC-9		466.56 Mbps
		OC-12	STM-4	622.08 Mbps
		OC-18		933.12 Mbps
		OC-24	STM-8	1.244 Gbps
		OC-36	STM-12	1.866 Gbps
		OC-48	STM-16	2.488 Gbps

Table 3-1: Transmission Rates (continued)

DS level	E level	OC level	STM equivalents	Line bit rate
		OC-96		4.976 Gbps
		OC-192		9.953 Gbps

- **DS.** Digital Signal hierarchy: standard signals used in the U.S. telecommunications industry.
- **E.** Standard signals used in the European telecommunications industry.
- **OC.** Optical Carrier; a SONET optical signal.
- **STM.** Synchronous Transport Module; depends on information occurring in regular and fixed patterns with respect to a reference such as a frame pattern.

Trap. A method used to isolate an abnormal condition or operation.

Trunk. A communication circuit or link that interconnects two entities, usually switching systems.

Trunk Card. An interface card used to connect a D50 multiplexer to the ATM backbone facility.

Tunneling. Refers to the encapsulation of a protocol within another protocol format that provides a datalink or path. Tunneling can be used as part of a private secure network via the Internet.

Twisted Pair. The term used to describe common copper telephone wire. The two wires are called Tip and Ring. Also called Unshielded Twisted Pair (UTP).

UBR (Unspecified Bit Rate). In ATM networks, a UBR connection transmits at variable rates. With UBR, specific bandwidth allocation is not guaranteed.

UBR+. Unspecified Bit Rate with minimum cell rate guarantee that allows a connection to burst up to peak cell rate.

UNI (User Network Interface). In ATM networks, one of three levels of interface.   A UNI specification which defines Layer 1 and Layer 2 protocols required for CPE and carrier equipment to interoperate. UNI specifications provide physical media and line rate implementation options.

UNIX. A multi-task, multi-user operating system developed by Ken Thompson of AT&T Bell Labs. UNIX is a registered trademark of Santa Cruz Operations.

UPC. The traffic control entity that monitors and enforces a virtual circuit's conformance with the source's traffic contract and parameters.

Upstream. Description of the communications path coming <u>from</u> the client/end user <u>to</u> the CO or DSLAM.

USB (Universal Serial Bus). The Universal Serial Bus is used in newer PCs. The bus is 12 Mbps and designed to be "plug and play." It supports multiple PC peripherals, including Nokia D50 compatible CPE with USB.

VBR (Variable Bit Rate). In ATM networks, a VBR connection transmits in bursts, at variable speeds.

VC Topology. Used in the Nokia D50's Craft Terminal software to set the direction and mode of communication for duplex, simplex egress, and simplex ingress PVC connections.

VCI (Virtual Channel Identifier). An identifier (value) in an ATM cell that identifies the data of one Virtual Channel connection from the data of another connection.

VDSL (Very-high-speed Digital Subscriber Line). VDSL provides DSL service at a data rate in excess of 10 Mbps (up to 52 Mbps). VDSL has a maximum operating range from 1,000 feet to 4,500 feet on 24-gauge wire.

VF. Voice Frequency – In telephony, the usable voice-frequency band ranges from approximately 300 Hz to 3400 Hz. Also, the bandwidth allocated for a single voice-frequency transmission channel is usually 4 kHz.

VoDSL (Voice over Digital Subscriber Line). An end-to-end voice transport technique integrating voice and data over DSL using special gateways that are designed to connect packetized voice traffic to Class 5 circuit switches.

VoIP (Voice over Internet Protocol). A technique for transmitting voice information in digital form in packets rather than the circuit-switch protocol of the public switched telephone network.

VPI (Virtual Path Identifier). An identifier (value) in an ATM cell that identifies the data of one Virtual Path connection from the data of another connection.

WAN (Wide Area Network). A WAN is a network of computers and related communications equipment whose elements may be in dispersed sites with distances great enough to require common carrier provided communication lines.

xDSL (all forms of Digital Subscriber Lines). The "x" represents the various types of digital subscriber lines: ADSL, RADSL, SDSL, HDSL, SHDSL, IDSL, or VDSL.

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Numerics