



Product information begins on page 2.

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Ascend

TECHNICAL BACKGROUND

DSL TNT: A Fully Integrated xDSL Concentrator

Version 1.0



This document provides a technical introduction and overview of the DSL TNT product line. For additional technical information on the DSL TNT please refer to the DSL TNT product documentation available on the Ascend FTP site.

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1. DSLNT Introduction

The DSLNT™ is a high-performance, standards-based xDSL concentrator designed for the large-scale DSL-based access requirements of Regional Bell Operating Companies (RBOCs) and Competitive Local Exchange Carriers (CLEC). The DSLNT provides a unique combination of feature richness, T3-level scalability and carrier-class robustness. With support for up to 240 DSL lines and a full range of access technologies, the DSLNT reduces rack space requirements while driving down price per port. Fully-compliant with existing network infrastructures, authentication standards and SNMP management protocols, the DSLNT was designed to integrate all your Layer-2 based transport services needs in a single, compact and easily managed platform.

The DSLNT has a modular architecture that can provide access to the Internet or global corporate network services. The chassis, line cards and network interface cards let you design custom configurations that satisfy a broad range of applications and bandwidth requirements; from medium density corporate LAN access needs, to large telephone company's central office. The DSLNT is a proven, reliable solution that utilizes the same core operating system code refined and proven in over 30,000 MAX installations in the world's leading carriers, PTTs and service providers.

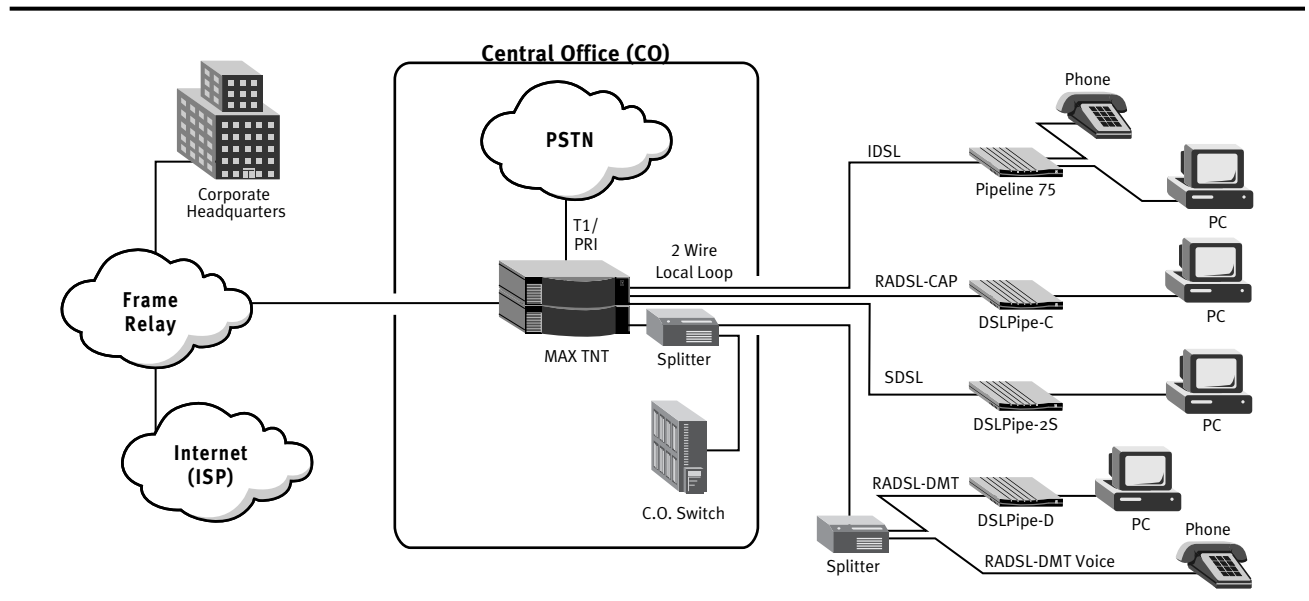


Figure 1 – Ascend's MultiDSL Solution

The unique DSLNT architecture allows easy integration of various xDSL technologies including RADSL-DMT, RADSL-CAP, SDSL and IDSL, while providing a smooth growth path into state-of-the-art WAN access technologies. The integrated design of the DSLNT saves you money by allowing you to aggregate xDSL networks into a single platform; providing bandwidth consolidation opportunities while minimizing the network management task.

With its flexible and scalable architecture, the DSLNT allows you to start with a single DSLNT shelf to address medium-density network requirements and expand with additional DSLNT shelves and WAN access technologies as user needs and preferences dictate. No changes in the chassis, core operating system or management software is required. Software options for the DSLNT allow you to add firewall and Virtual Private Networking capabilities for security and added revenue or cost saving opportunities.

Ascend established the following design goals when creating the DSLNT:

Design Objectives	How DSLNT Achieves Objectives
Layer-2 Services	Layer-2 transport services using Frame Relay ensures that RBOCs and CLECs can offer clear data services to customers without having to deal with IP addresses and protocols.
High-Speed Access Services	<ul style="list-style-type: none"> • Up to 7.0 Mbps downstream and up to 1.0 Mbps upstream using RADSL on a single pair of local loop. • Up to 1.54 Mbps Symmetric on two pairs of wires or up to 768 Kbps on a single pair of wire using SDSL. • Up to 128 Kbps Symmetric on a single pair using IDSL.
Compatibility with existing network infrastructure	Support for all standard WAN and LAN access media and muxing protocols, as well as authentication, accounting, security and SNMP management standards
High reliability	Three-shelf architecture with integrated relays for redundancy on intershelf bus; Redundant, hot-swappable power supplies; distributed processing; hot-swappable line cards; expandable memory sufficient to store multiple software images for fail-safe software upgrades; redundant DS3 support; support for internal and external clocking – with a stratum 4 internal clock.
Security	Support for RADIUS, TACACS/+, PAP, CHAP, Token-based security, ATMP and PPTP and optional built-in firewall software. Planned implementation of L2TP, L2F and IPSec encryption
Flexibility	Slot-independent support for all popular LAN and WAN media including: 10Base-T, 100Base-T, T1, E1, DS3, HSSI, serial, IDSL, SDSL and RADSL-DMT and RADSL-CAP. Add the line cards you need, when you need them.
High-performance with cost-effectiveness.	Multiple High-speed RISC CPUs, distributed processing support and route caches on every expansion module. High-capacity and multi-access speed support results in industry-leading performance and price per port for this class of access switch.
Scalability/High Capacity	Support for the broadest range of access speeds: 52 Mbps High Speed Serial Access (HSSI), T1/E1 to DS3 speeds on the WAN, 10Base-T and 100Base-T on the network interface, and 7 Mbps RADSL for client access. Start with a single chassis and expand as needed. Support for up to three 16-slot shelves per DSLNT system and up to 240 DSL lines.
Manageability	Ascend's NavisAccess™ software for comprehensive network management, SNMP management, support for Telnet, Syslog.

2. Applications

The DSLTNT was designed for various applications:

- Layer-2 End-to-end transport services
 - Virtual Private Networks (VPNs) for corporations
 - VPNs for ISPs
- Internet access
- High-speed access for multi-tenant buildings
- Campus connectivity
- Low cost Fractional T1 Frame services

In each of these applications the DSLTNT provides unparalleled scalability, flexibility and minimized total cost of ownership.

It is well established that network and Internet access requirements are growing rapidly, WAN and client access technologies are evolving quickly and there is significant pressure on organizations to minimize the total cost of ownership of their WAN solutions.

Layer-2 End-to-End Transport Services

RBOCs and CLECs, while co-locating the DSLTNT in the central office, are generally not permitted to perform Layer-3 based routing. Instead, they are permitted to offer Layer-2 based transport services to maintain fair competition. Therefore, data that is received by the DSLTNT on the MultiDSL™ line (IDSL, SDSL, RADSL) must be forwarded transparently at Layer-2 to the network connection such as T1/E1/PRI, DS3, HSSI, SWAN etc.

In order to offer Layer-2 based transport services, the protocol on the MultiDSL lines can be either Frame Relay or ATM. Since ATM on the MultiDSL line is not popular at this point, any service provider offering ATM over MultiDSL line will end up spending lot of money in educating the mass market on this new technology. Therefore, a very pragmatic and cost-effective approach would be to offer Frame Relay over MultiDSL line while using either Frame Relay or ATM as the connection to the backbone network on the trunk line.

The DSLTNT permits mapping the incoming DLCI (on the MultiDSL) line to the outgoing DLCI (on the trunk line) as one-to-one PVC mapping. This facilitates RBOCs and CLECs to offer transparent Layer-2 based transport services. Additionally, this off-loads RBOCs and CLECs from having to assign and manage IP addresses for the end users at the Central Office (CO).

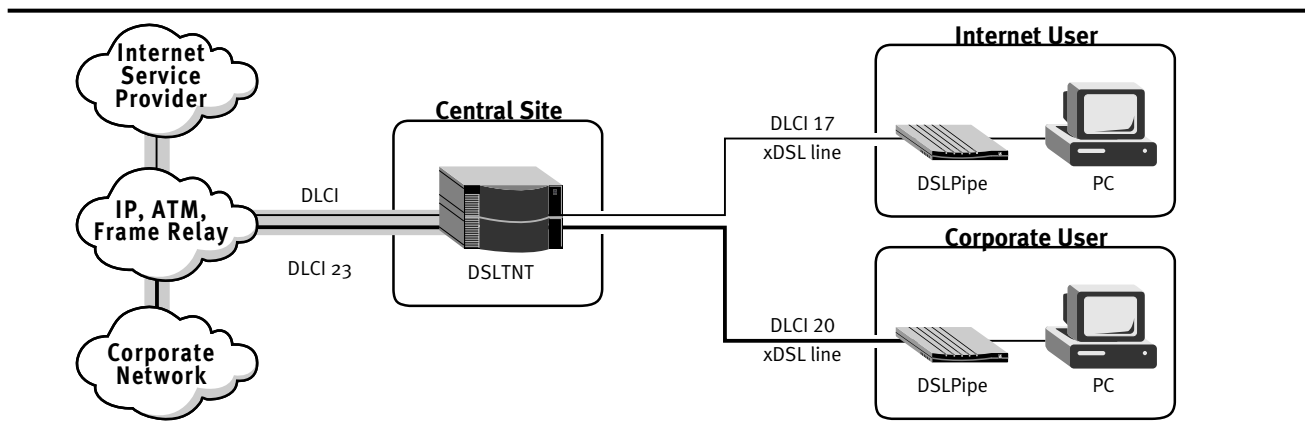


Figure 2 – The DSLTNT allows RBOCs and CLECs to offer transparent Layer-2 based transport services.

RBOCs and CLECs can deliver Layer-2 based high-speed connectivity to Internet Service Providers (ISPs) and corporate customers. This service is secure since each end user has a dedicated PVC end-to-end. Additionally, the ISPs and corporate customers can assign and manage their own IP addresses to their end users.

In a corporate environment, the type of data on the network may be IP, IPX, NetBios or anything else for that matter. When Layer-2 transparent services are provided by the RBOCs and CLECs, the customers are not restricted to any one protocol and this is accomplished by setting the DSLPipe™ IDSL router/bridge to bridging mode. Since DSLPipe units perform intelligent bridging, they learn the MAC addresses on the LAN segment and therefore forward only those frames that do not belong to the local LAN segment to on the MultiDSL line. This intelligent bridging optimizes bandwidth utilization while performing bridging operations.

ISPs may also, either rent MultiDSL ports from the RBOCs and CLECs, or partner with them to offer high speed Internet services to the end users. In either case, each user is connected via a MultiDSL line using frame relay PVC all the way to the ISP's Point of Presence (POP) where the data is further forwarded to the Internet. The ISPs can manage their own IP address assignment to the end users while the data remains transparent to the RBOCs/CLECs who provide the transport services.

Internet Access

The DSLTNT, being a very flexible and feature rich platform, service providers such as Independent Telcos and ISPs may take advantage of the PPP and Frame Relay support to offer Layer-2/3 multiplexing.

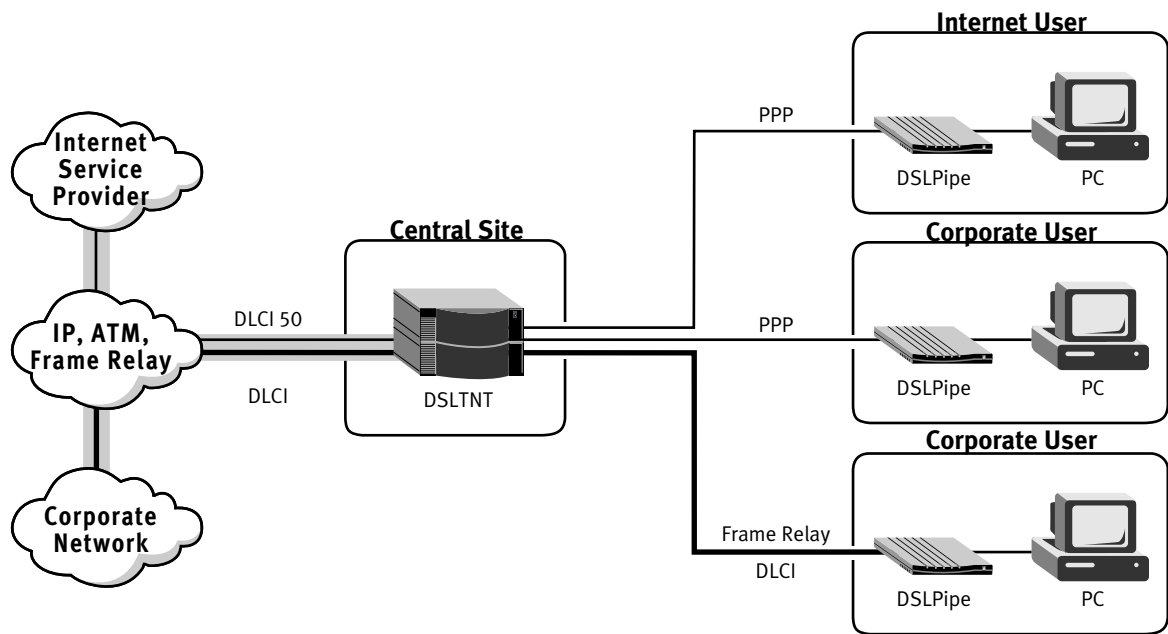


Figure 3 – The DSLTNT lets service providers take advantage of PPP and Frame Relay support.

Generally Internet service providers perform authentication of their customers for tracking purposes as well as accounting purposes to monitor the traffic load on their networks. Predominantly, ISPs have already standardized on RADIUS authentication and accounting servers. These servers are used in conjunction with PPP and Multilink PPP protocols for the PAP and CHAP authentication and of the users as well as for accounting. The MultiDSL lines form the DSLTNT may be configured for PPP or Multilink PPP to leverage all the benefits that are available while using this protocol, including dynamic assignment of IP addresses to end users and dropping the logical connection upon inactivity for a configured period of time.

As shown in the diagram, the PPP sessions may be terminated at the DSLTNT and the data may be forwarded to the backbone network via Frame Relay links.

High-Speed Access for Multi-tenant Buildings

Service providers including RBOCs, CLECs and ISPs may also take advantage of the existing twisted pairs that are available within a high rise building or a multi-dwelling apartment complexes.

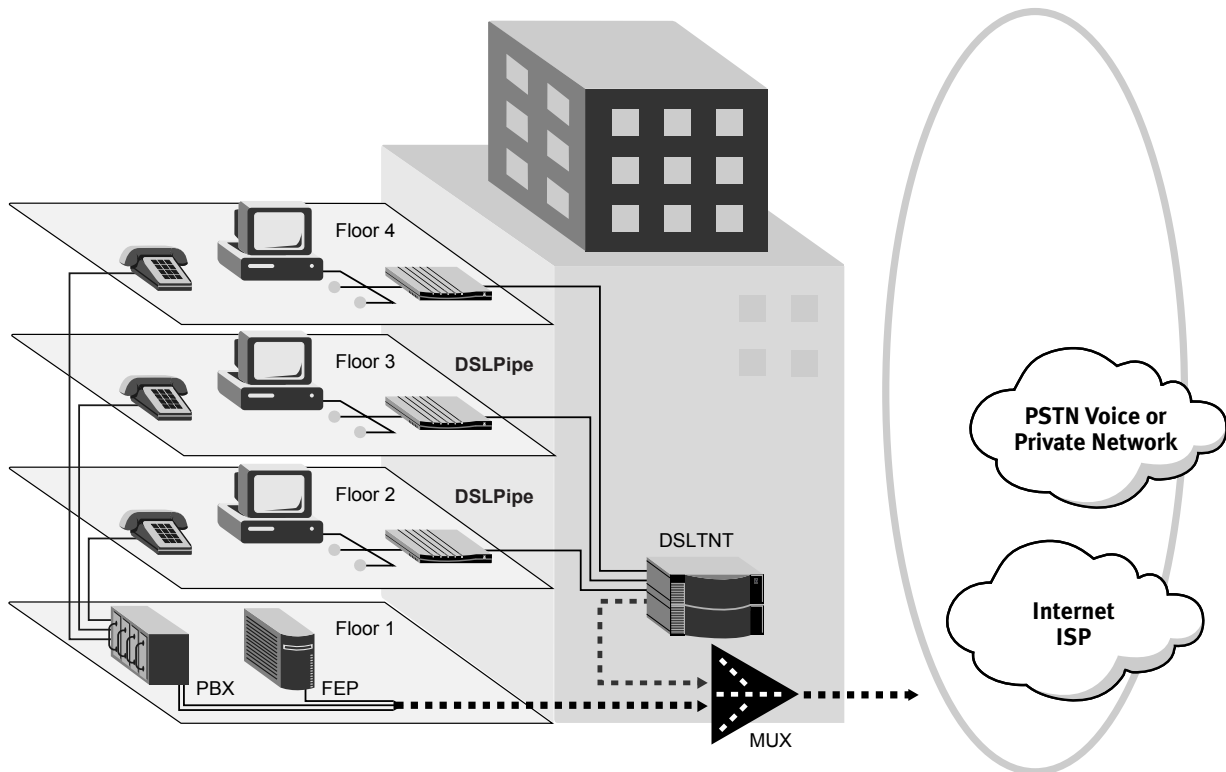


Figure 4 – Service providers can leverage the existing twisted pairs to offer xDSL services in multi-dwelling buildings.

In this application, the service providers no longer have to deal with all the loop issues generally associated with the local loop based DSL services.

The service providers can quickly offer a DSL based high-speed Internet access to users residing in a multi-dwelling apartments. The service providers, by working with the property management, may install a DSLTNT in the wiring closet and connecting the available unused twisted pairs to the appropriate MultiDSL line cards on the DSLTNT and offer services from 128 Kbps to 7.0 Mbps. In cases where the twisted pairs are already in use for telephone connections to the users which are lifeline POTS, RADSL based services may be offered by installing the passive voice splitters and integrating the lifeline voice and ADSL data on the same line.

Of course, the connection from the DSLTNT to the Internet may be via dedicated Frame Relay connection to the Internet or via a SONET Mux which exists near most of the high rise buildings.

Campus Connectivity

In an University environment or a corporate campus, there are several buildings and departments that need to be interconnected seamlessly to the computer room. This is generally LAN-to-LAN connectivity. Although it is possible to simply extend the LAN cable to every building, the distance limitation on the LAN cable may permit to install LAN cables across to every building.

The other alternates to connecting the buildings include fiber optic cable and DSL. As we all know, installing fiber optic cable to connect all the buildings and departments is cost-prohibitive. Corporations have tremendous and constant pressure to reduce the expenses and fiber optic cable is not a cost effective solution.

Therefore, MultiDSL serves this application very well due to (1) longer reach than a LAN cable can deliver and (2) cost effective solution since MultiDSL leverages the existing twisted copper pair between buildings and departments.

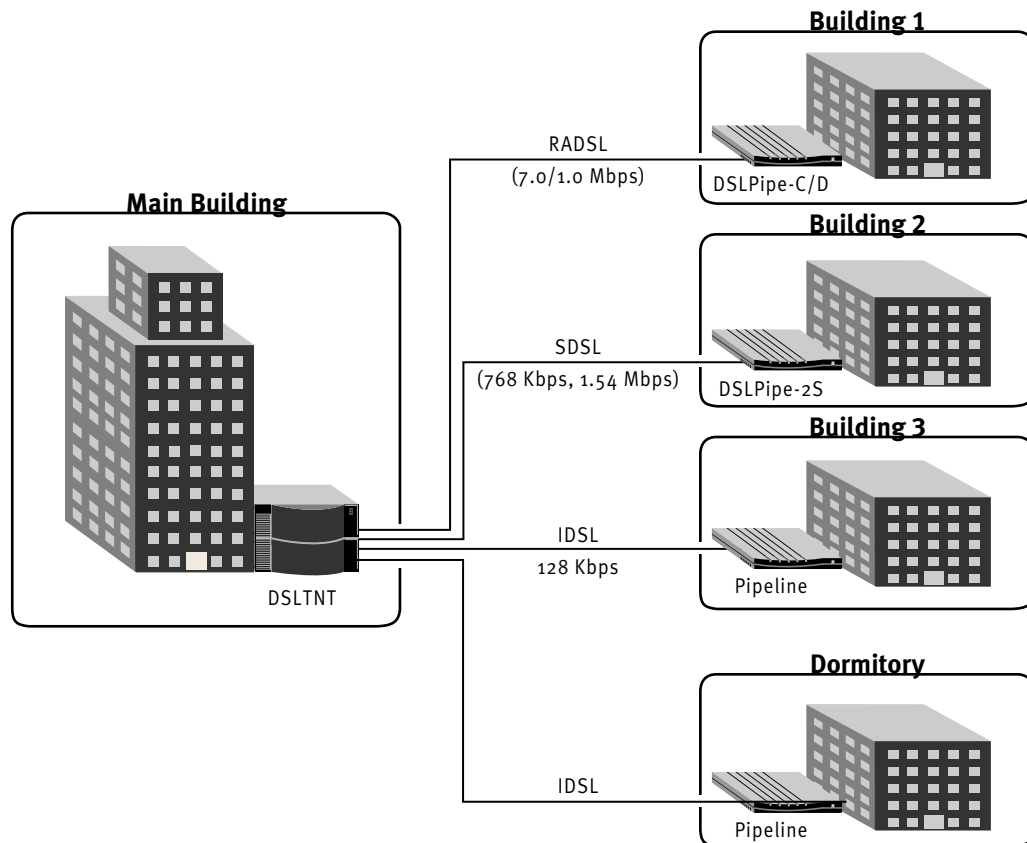


Figure 5 – By bridging all the LANs on the MultiDSL lines using DSLTNT delivers a seamless connectivity in a campus environment.

Low Cost Fractional T1 Frame Services

Frame Relay is one of the hottest services today offered by Carriers and other service providers. Fractional T1/E1 and T1/E1 based Frame Relay services such as 64 Kbps and 128 Kbps are used by small/medium ISPs as well as small and medium corporations for Internet and Intranet connectivity. The biggest market is in the fractional T1/E1 services.

In today's environment, carriers offering fractional T1 based Frame Relay services need to install a full T1 circuit and block the unused bandwidth. The T1 circuits are 4 wires and is also very expensive since the wires need to be conditioned and T1 repeaters need to be installed for every few thousand feet. Even though it may be a fractional T1 services, it still incurs the cost of a full T1 circuit as far as facility is concerned.

Also fractional T1 circuits use up the most scarce resource in the CO facility i.e. the local loops.

Now the carriers can increase their profit margin by decreasing the cost for the Fractional T1 circuits using MultiDSL. Unlike the traditional fractional T1 circuits, MultiDSL

(1) uses dry copper pair (2) does not require expensive repeaters (3) uses single pair of wires (4) costs around 10 times less than a T1 circuit cost and (5) speeds far greater than T1 may also be offered, i.e. 7.0 Mbps, on the same pair of wires.

3. Architectural Overview

Chassis

The DSLTNT chassis is a powerful, compact system that has been designed to allow RBOCs, CLECs and CAPs to aggregate a broad array of access media in the limited space in the Central Office (CO). The DSLTNT eliminates the need for miscellaneous access equipment from a multitude of vendors and allows a single, expandable and easy-to-manage DSLTNT shelf to provide a complete offering of network access services.

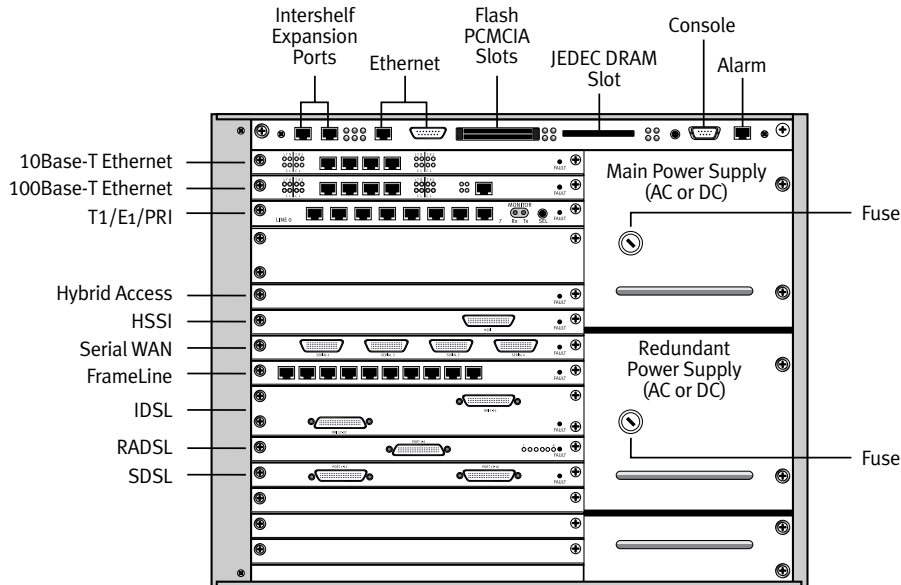


Figure 6 – The DSLTNT supports virtually all access standards in a single compact chassis.

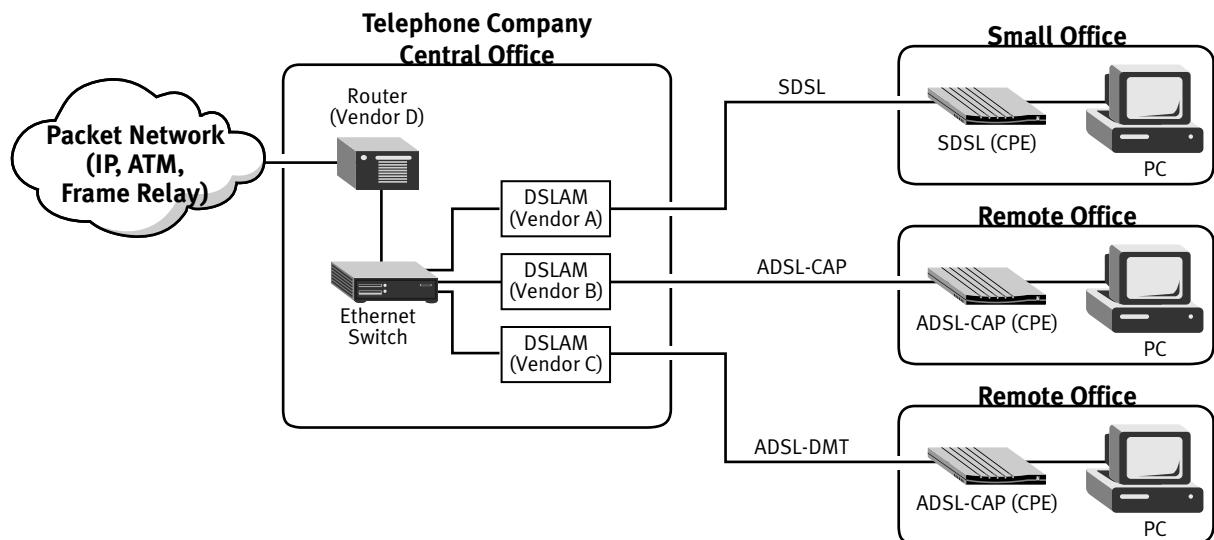


Figure 7 – Multi-access Network without DSLTNT. The historic approach of using discrete components to address your access needs results in an expensive, complex access network.

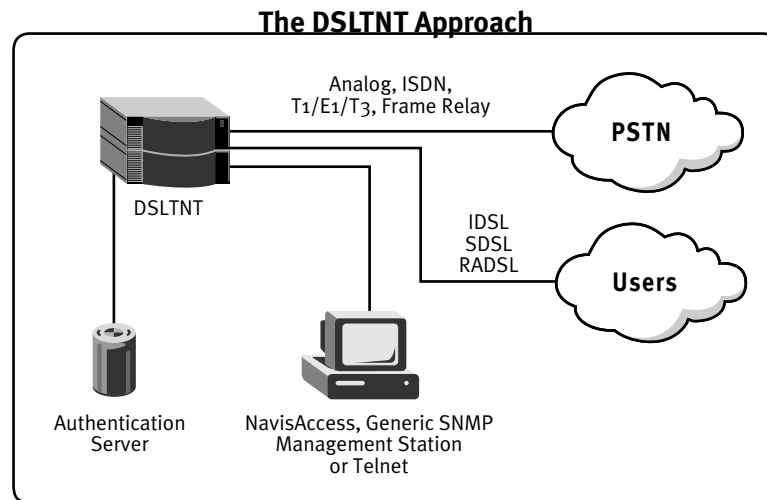


Figure 8 – Multi-access Network with DSLTNT

Without the Ascend DSL solution, there are several obvious issues for the service provider:

- High initial investment due to several stand-alone equipment
- Major interoperability issues due to equipment from different vendors
- Waste of expensive and scarce co-location space at the central office
- Lack of data privacy due to DSL modem based DSLAM – potential financial risk

In addition, there are hidden costs and issues such as:

- Need to add additional power distribution to accommodate multiple standalone equipment
- Need to add additional air conditioning system
- Lower port density due to lack of space
- Higher total cost of ownership

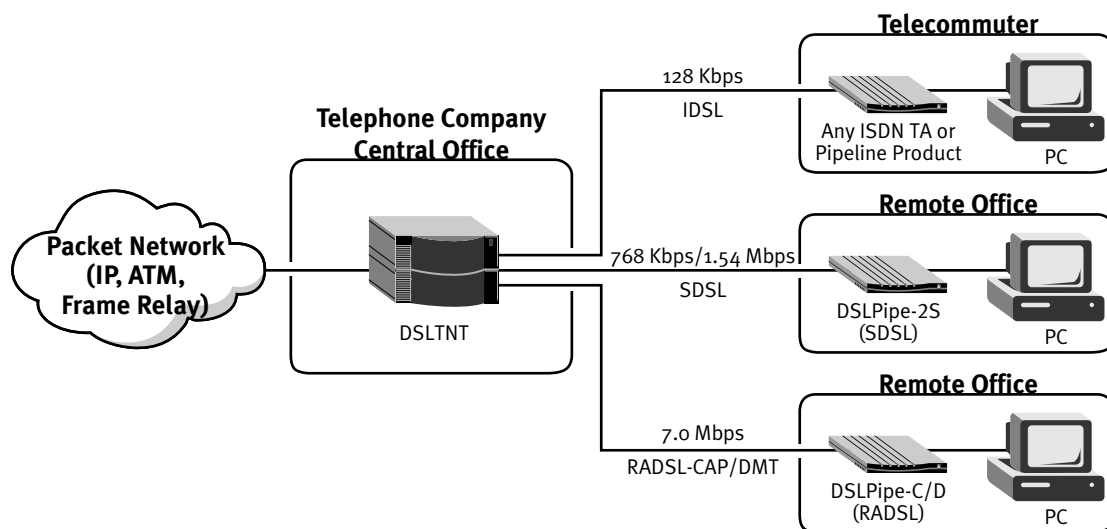


Figure 9 – The DSLTNT supports IDSL, SDSL and RADSL-CAP/DMT in one compact chassis.

The Ascend Architectural Benefits:

1. Cost effectiveness, due to access line consolidation and access technology integration
2. Reduced network management overhead due to simpler, integrated WAN network and single standardized management interface
3. Reduced network support costs due to simplicity of WAN access solution
4. Increased responsiveness to user needs due to simple, incremental additions to WAN capacity via modular design
5. Increased network security due to optionally integrated firewall, fewer points of network access and simplified WAN network design

Every DSLTNT has a shelf controller module preinstalled and 16 option slots that can be populated with any of the available DSLTNT line cards and network interface cards. All cards are treated as peers, making the DSLTNT ideal for Layer-2 transport services and community VPNs for corporations.

The DSLTNT has been designed for Network Equipment-Building System (NEBS) Level-3 compliance and can be placed in central office sites or standard telephone closets. Standard 19 inch (or optional 23 inch) rack mount ears can be used to accommodate your rack mount closet standard.

For power, the DSLTNT chassis can be outfitted with single, or dual power supplies of either AC or DC voltage. These hot swappable and load-sharing power supplies provide the redundant power option that the highest availability sites need.

The DSLTNT provides the broadest array of expansion cards in the industry; it accommodates existing access standards such as 10/100Base-T, HSSI and Frame Relay, while also addressing the increasingly number of new access standards such as IDSL, SDSL and RADSL. Each expansion module incorporates its own high-performance RISC processor so that the DSLTNT system resources scale as you expand the functionality. By simply adding new expansion modules you can quickly and seamlessly support new services and new technologies; obviating the need for additional external equipment and training, while avoiding potential integration challenges.

Backplane

For maximum performance the DSLTNT incorporates three buses in its backplane design and interconnects these buses on each chassis with inter-shelf links that run between the shelf controllers on each of DSLTNT shelves. Each bus is optimized for a specific type of data traffic and provides a high-throughput architecture for simultaneous control, TDM and packet data.

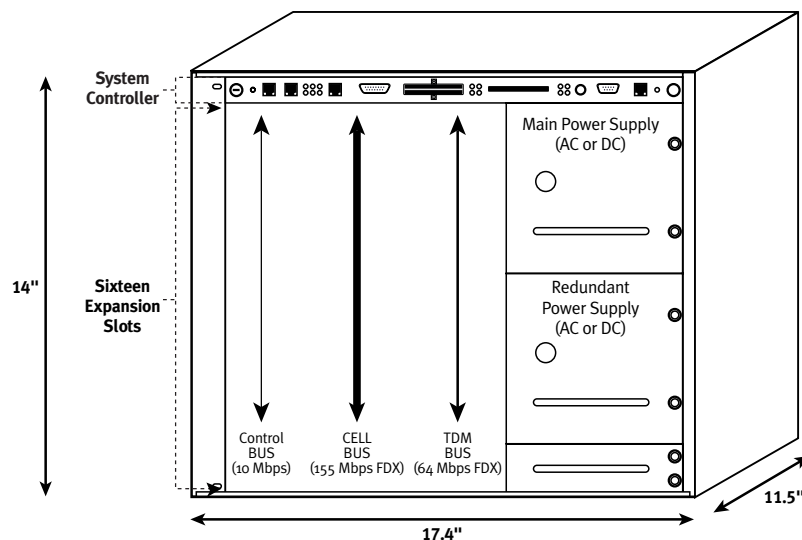


Figure 10 – Physical representation of a DSLTNT shelf

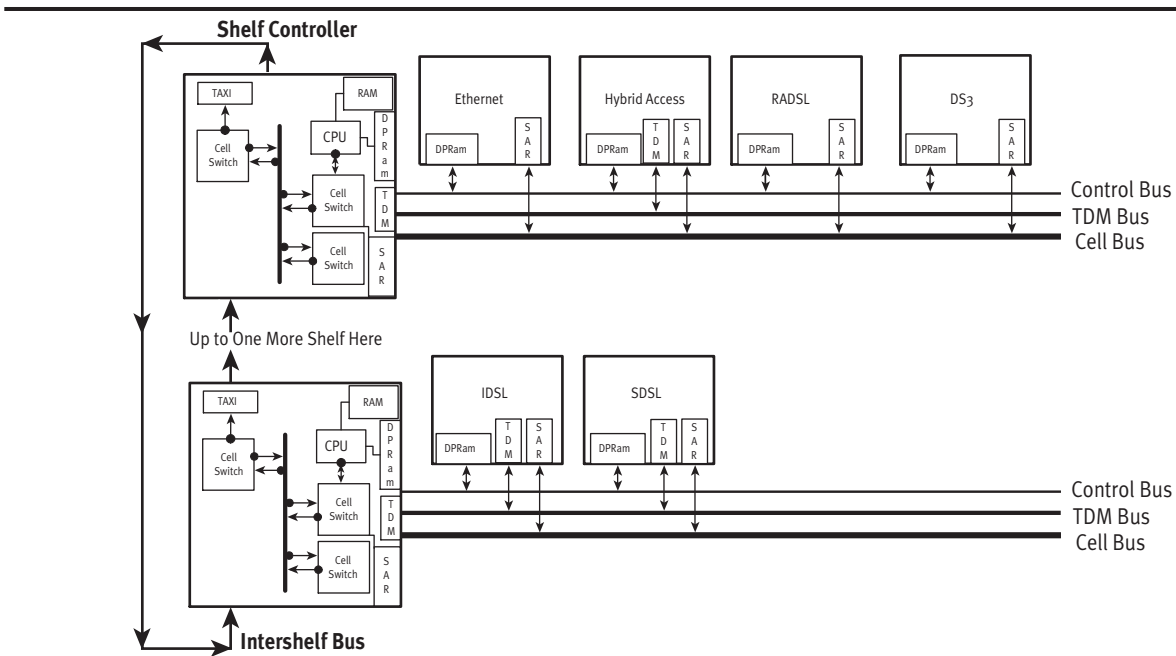


Figure 11 – Logical representation of DSLTNT Intra-shelf and Inter-shelf Buses

Control Bus

The control bus is a 10 Mbps module-to-module communications link that is used for exchange of control and configuration information between the shelf controller and expansion cards. It is also the channel for distribution of software (or image files) from the shelf controller to each of the expansion cards. The control bus is a dual-ported memory access channel which allows rapid and direct full-duplex communications between the CPU on the Shelf Controller and the CPUs on all the DSLTNT expansion cards. The Control bus connects the Shelf Controller to the expansion cards in a virtual star configuration so there is never any bus contention. Whenever a DSLTNT chassis is powered up the Shelf controller module communicates across this bus to determine what expansion modules are in the DSLTNT chassis and whether each of the modules in the DSLTNT chassis has the correct operating software and configuration information. If new operating software or configuration information is needed, it can be quickly downloaded from the shelf-controller to the appropriate modules over this bus.

The control bus is also used by the Shelf controller module to monitor the status of, and provide operating instructions to, all the other cards in the DSLTNT chassis in real-time.

The Control bus is comprised of two discrete segments; the Intrashelf bus (within the DSLTNT chassis) and Intershelf bus (between each DSLTNT chassis). While most communications over the control bus will take place on a given shelf's intrashelf control bus, there are also on-going communications between the Master shelf controller and the other shelf controllers and expansion modules in the other shelves. This inter-shelf communication is accomplished by muxing the information over the high-speed intershelf cell bus that links up to three DSLTNT shelves.

TDM Bus

The DSLTNT TDM Bus is a 64 Mbps bus for circuit-switched voice/data. The TDM bus was designed for rapid transfer of inbound or outbound traffic directly to, or from, other expansion modules. This approach maximizes throughput by avoiding the data/voice format conversion and transfer delay that many products have. The TDM bus supports 1024 full-duplex 64 Kbps time slots (or subrates of 64 Kbps) and can multiplex DS0 channels independent of data/voice origination. The TDM bus is used to forward voice calls either from/to an IDSL line card or SDSL line card.

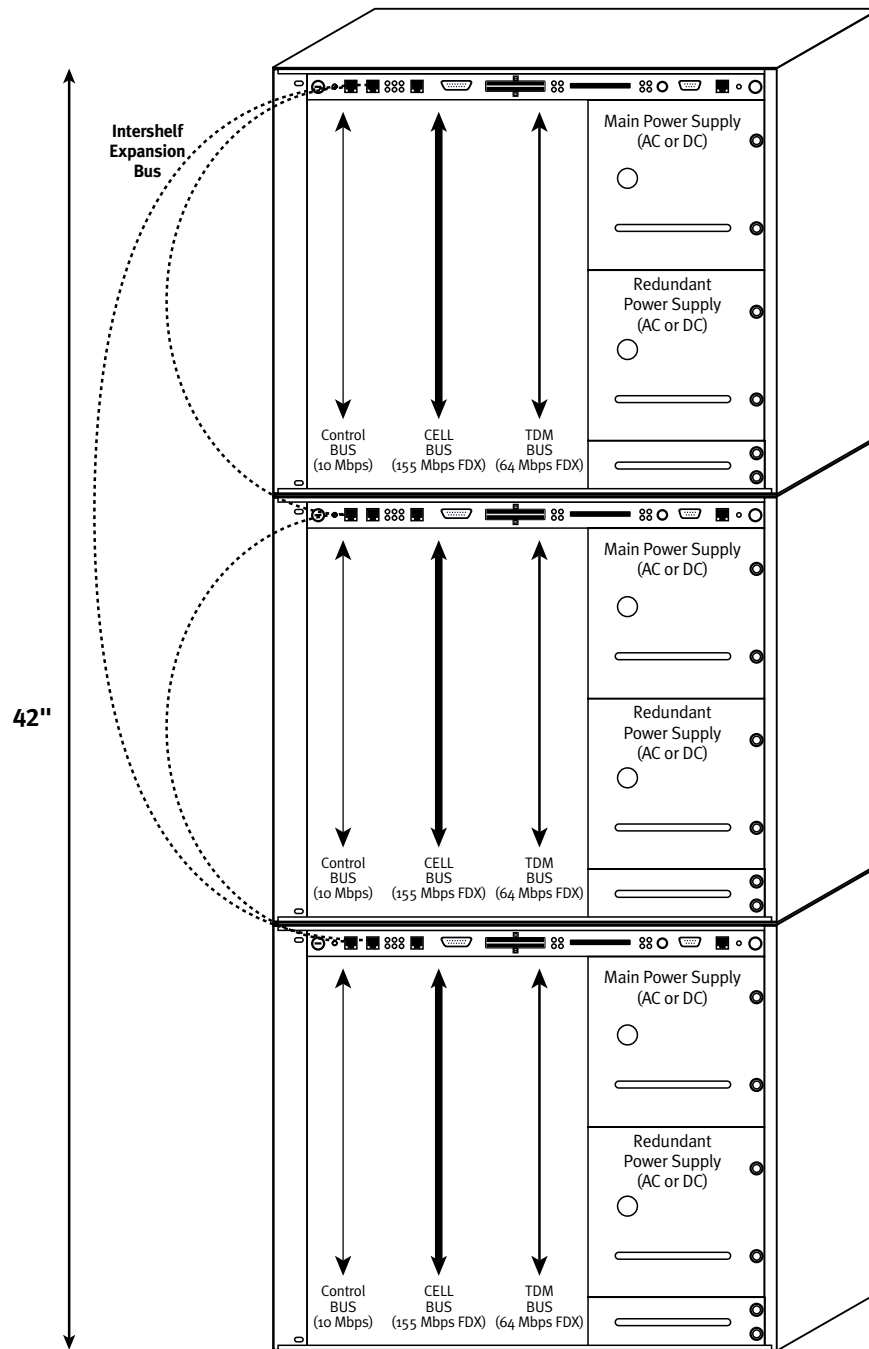


Figure 12 – The control Bus, Cell Bus and TDM Bus are extended between shelves via the Intershell Bus.

As with all the DSLTNT buses, there are two implementations of the TDM bus; the Intra-shelf TDM bus, and the Inter-Shelf TDM bus. The Inter-Shelf bus is implemented via the Shelf Controller modules, provides a full 64 Mbps data path and is implemented using the TAXI (Transmit and Receive Interface) Cell technology. The Intershell TDM bus transfers data over the twisted pair cable going between each of the Shelf controllers. The Intershell bus provides full redundancy/backup protection because of its closed loop design; each DSLTNT shelf provides a default with cut-through relays to insure that a non-communicative shelf does not interrupt communications between any of the other shelves.

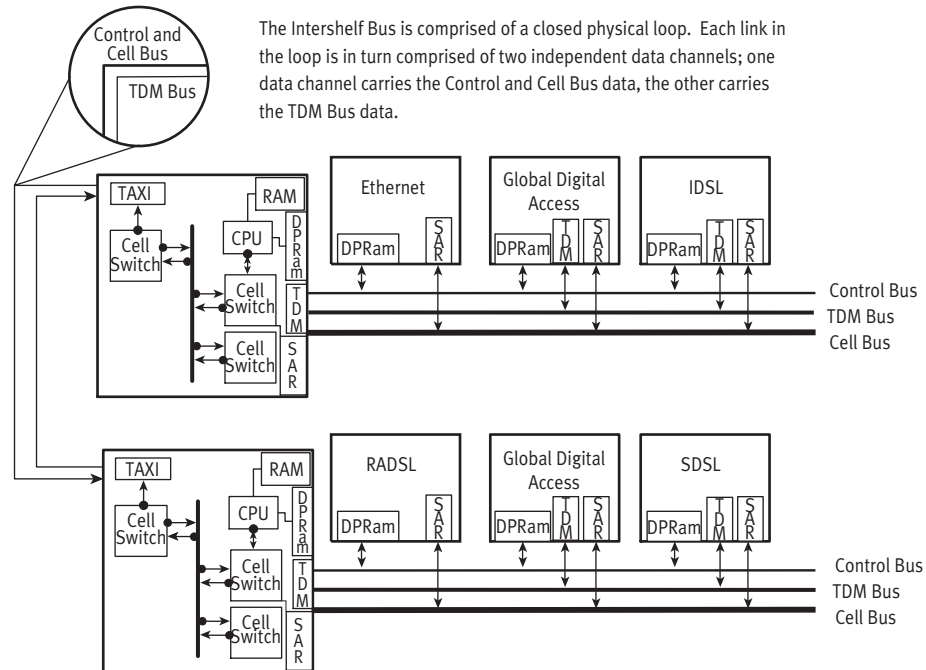


Figure 13 – Intershef Bus

The TDM intershef bus is incorporated within a single custom twisted pair cable with the other intershef buses and must be part of a closed physical loop that passes through all the Shelf controllers in the two or three shelf DSLTNT system (see figure 14).

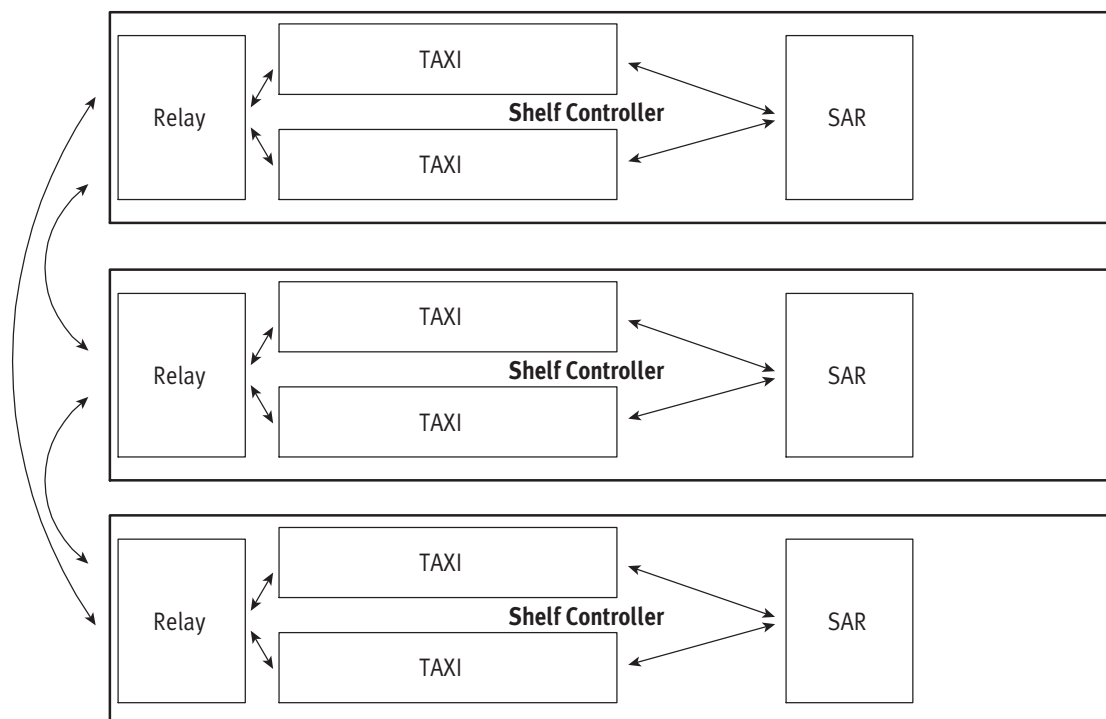


Figure 14 – Intershef Bus – Cut-through relays improve reliability.

Cell Bus

The 155 Mbps cell bus is a high-speed, full-duplex, non-blocking, non-collision based path between the DSLTNT modules. Whenever data from any of the expansion modules (DS3, T1/E1, etc.) needs to be routed across the back-plane in packet form, that data is transported over the Cell bus. Multiple shelves in a DSLTNT system can operate logically as a single large system. There is no delay penalty for forwarding data between modules in different shelves as compared with forwarding data between modules in the same DSLTNT shelf.

To communicate on the cell bus each DSLTNT expansion module has a Segmentation And Re-assembly (SAR) chip that breaks IP (or other Layer-3 protocol) packets or reassemble incoming packets into cells and forward them to their destination on the cell bus. Each shelf controller has a Transparent Asynchronous TX/RX Interface (TAXI) driver circuit that drives the intershelf cell bus in a redundant loop interface (see above Figure 14).

Every shelf controller has three high-speed Cell multiplexors that direct these to their destinations – either on the local cell bus or over the intershelf link to one of the other DSLTNT shelves.

4. Digital Subscriber Line Types

Today's Digital Subscriber Line (DSL) services are accessed from your location through a network access line. Ascend DSLTNT systems integrate a dynamic mix of network access lines:

- IDSL
- SDSL
- RADSL-CAP
- RADSL-DMT

IDSL Access

Ascend now offers ISDN Digital Subscriber Line (IDSL) support via DSLTNT line cards that provide “always on” (nailed-up) digital data circuits. Ascend supports voice services over IDSL also. These lines each contain two 64 Kbps data channels (B-channels) that can be used for data independently, and a single out-of-band signaling channel (D-channel).

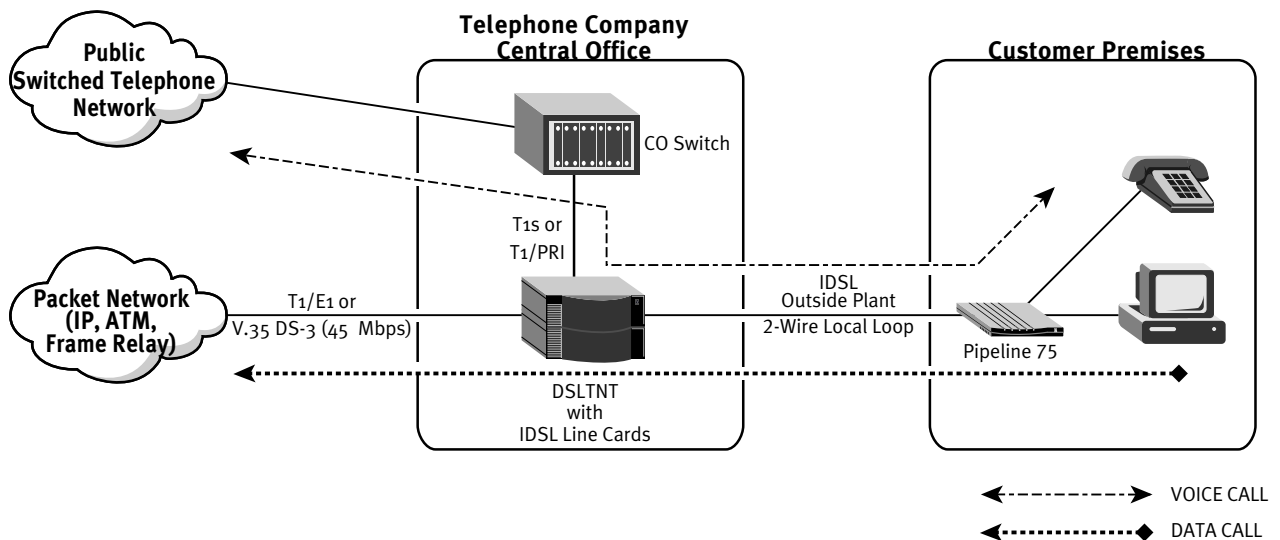


Figure 15 – IDSL addresses data and voice needs.

Unlike ISDN lines IDSL lines provide data services that do not burden the traditional telephone company central office switches, instead the packet data is directly routed to the data network and only the voice service are switched onto the traditional telephone switches. Because the IDSL card in the DSLTNT is splitting off the data before it reaches the central office switch, the DSLTNT must be co-located in the Telco's central office or can be used in a corporate building/high-rise or college campus environment where telephone wiring is available over significant distances and high-speed internetworking support is desired.

IDSL lines are an ideal addition to a carrier's service offering as an inexpensive voice and data service. From an end-user standpoint IDSL is an ideal solution for the small office or medium-sized business that wants to host a Web server at its office, and have full-time Internet connectivity (and voice connectivity) at a reasonable cost.

The key benefits of Ascend's IDSL are:

1. Voice and data support over a single pair of wires without an expensive CO switch upgrade
2. User-configurable data channel pre-emption for incoming voice calls (so as to allow important phone calls through even though B-channels may be busy with data transfer)
3. Up to 18,000 ft. transmission distance on standard local loop
4. Transparency of "U" loop repeaters and Digital Loop Carriers (DLCs) to IDSL technology means that distances beyond 18,000 ft. are supported by using standard local loop extension devices.
5. Compatibility with any ISDN terminal adapter or router for IDSL circuits with data-only service
6. 64 Kbps or 128 Kbps Frame Relay service over a single pair of wires saves the scarce and expensive resource – copper pair (traditional 56 Kbps and 128 Kbps Frame Relay services require 2 pairs of wires)
7. Protection of customers' investment in their existing ISDN CPE

IDSL lines work with all regular ISDN CPE equipment (such as the Ascend Pipeline series of bridge/routers and terminal adapters) without special configuration.

SDSL

SDSL line cards can be installed in the DSLTNT or MAX TNT at the CO to support up to 240 SDSL ports. In this application, end users can connect their Ascend's DSLPipe-S units to the carrier's network. The connection speed is 768 Kbps over a twisted pair for a distance of up to 12,000 feet. The DSLTNT is a multiservices platform that lets carriers and service providers offer analog, ISDN, IDSL, SDSL, HDSL and RADSL services using a single unit.

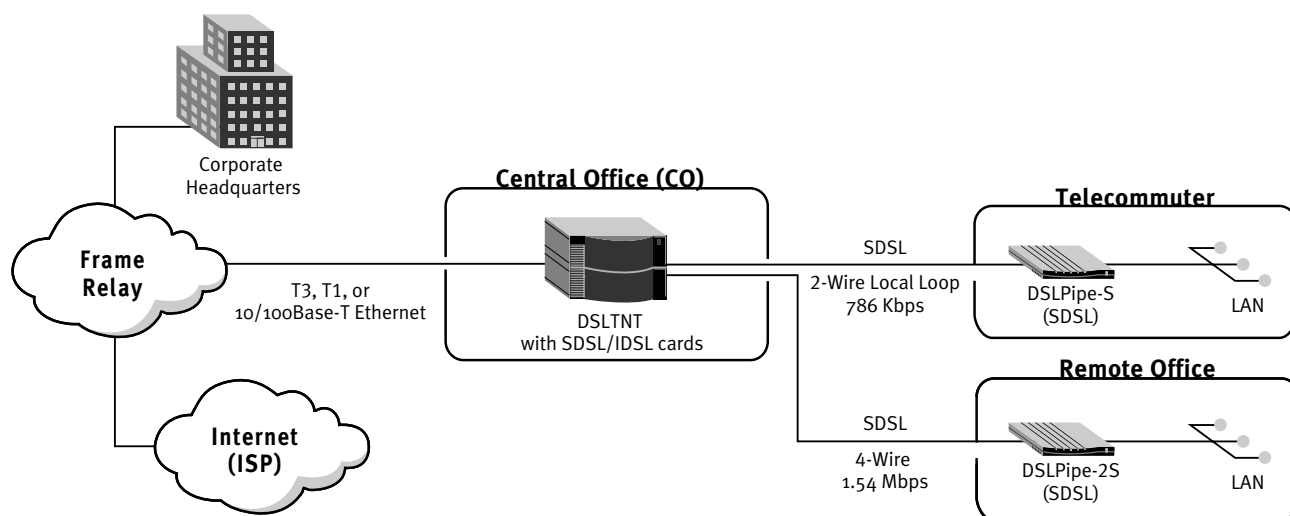


Figure 16 – SDSL solutions for end user application

RADSL

RADSL line cards can be installed in the DSLTNT or MAX TNT at the CO to support up to 90 RADSL-CAP ports. In this application, the end users can connect their Ascend DSLPipe-C or DSLPipe-D unit to the carrier's network. The connection speed is 7 Mbps downstream and 1 Mbps upstream over a twisted pair at a distance up to 10,000 feet, 2.5 Mbps downstream and 1 Mbps upstream for up to 12,000 feet. For distances up to 17,000 feet, the connection speed is 640 Kbps downstream and 544 Kbps upstream. RADSL technology ensures that maximum data rate is achieved especially in a noisy line condition.

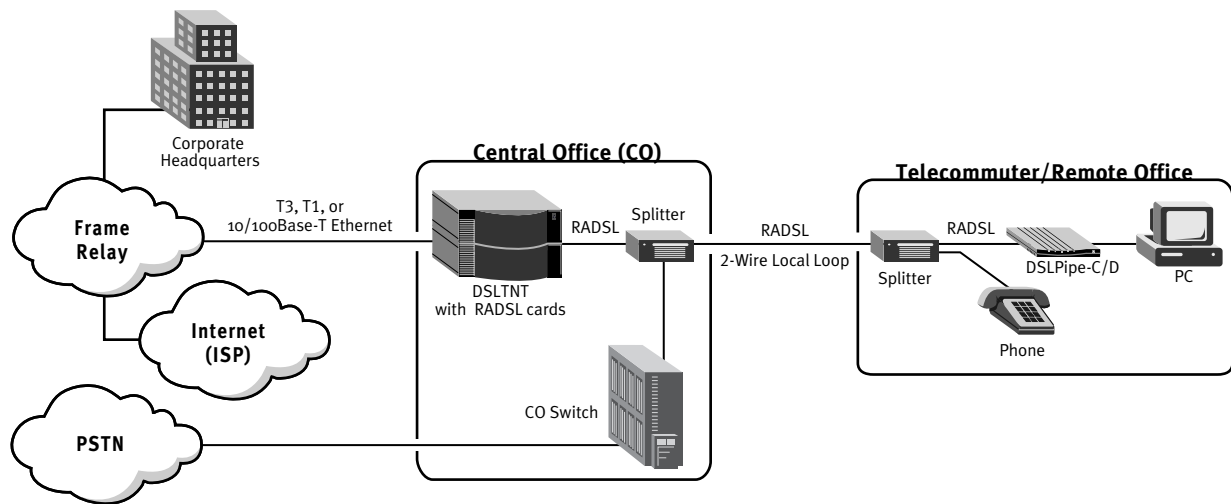


Figure 17 – RADSL solution for central office and end user applications

ISDN PRI Access Lines (in North America, Japan, and Korea)

Primary Rate Interface (PRI) lines – Each consist of 23 64 Kbps channels (B-channels) and a single 64 Kbps out-of-band signaling channel (D-channel). They can connect to standard voice, ISDN Multirate, Switched 1536, Switched 384, Switched 64, or Switched 56 services.

ISDN PRI Access Lines (Outside of North America, Japan and Korea)

These lines each contain 30 64 Kbps channels (B-channels) and two 64 Kbps out-of-band signaling channels (D-channels) for a total throughput of 2.048 Kbps. They are based on the CEPT G.703 (E1) standard. They can connect to standard voice, ISDN Multirate, Switched 1536, Switched 384, Switched 64, or Switched 56 services.

E1-R2 Access Lines

E1 access lines are available throughout Asia, Eastern Europe, China and Latin America. These lines support 30 data channels and one signaling channel.

T1 Access Lines

T1 access lines are 1.544 Mbps lines (1.536 Mbps actual user bandwidth plus 8K of framing bits) which have 24 channels, each with 56 Kbps of user bandwidth and 8 Kbps of in-band signaling. Each of these channels can be used to access the standard voice network, the Switched 56 data network, or routed as non-switched leased circuits between two points. Ascend DSLTNT systems can connect to T1 access lines to provide access to switched 56 services or dedicated circuits (such as leased 56, fractional T1, or full T1).

E1 (G.703) Access Lines

E1 is used in Europe like T1 line is used in the United States. Instead of 24 channels combined on a 1.536 Mbps link, E1 time division multiplexes 32 channels of 64 Kbps for a combined bandwidth of 2.048 Mbps. One of the 32 channels is used for signaling and one for frame alignment, and the remaining 30 are used for actual user bandwidth.

DS3 Access Lines

DS3 circuits, provide approximately 45 Mbps of user bandwidth.

Global Digital Access

Global Digital Access is an optional hardware feature that gives users flexible digital access via the T1/E1 or ISDN/PRI interface. With this hardware option the DSLTNT supports HDLC processing for those circuits that need it; such as ISDN PRI signaling, Frame Relay etc. NSPs and corporations must frequently expand their capabilities to meet new user requirements. Global Digital Access allows just this type of evolution for analog-focused sites.

Frame Relay Layer-2 Services

DSLNT is a concentrator designed for co-location in the CO. It allows RBOCs and CLECs to offer services to corporate customers and Internet Service Provider customers. In either case, DSLNT permits forwarding of incoming data, irrespective of protocol, to the outgoing trunk. This ensures that the RBOCs/CLECs do not have to deal with IP addresses or protocol related issues. It simply multiplexes and demultiplexes DLCIs on DSL lines and Frame Relay based trunks.

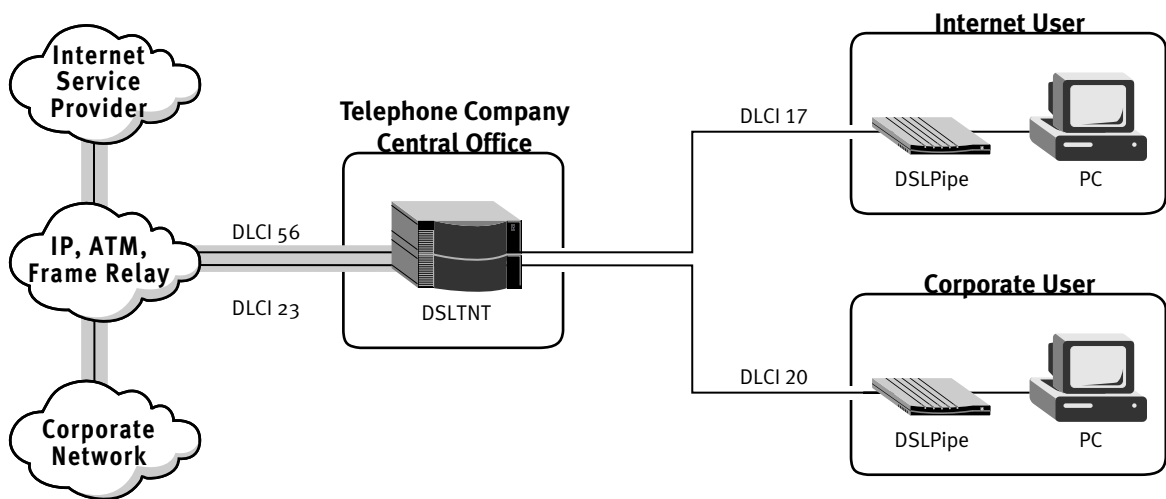


Figure 18 – Corporate users are linked to corporate network, while Internet users are linked to ISPs transparently across a DSLTNT. Up to 4096 Frame Relay DLCIs per DSLTNT is supported.

5. DSL TNT Management

The Ascend DSL TNT supports several sophisticated management mechanisms, including integrated SNMP management applications, as well as the more traditional management approaches such as VT100 and Telnet.

NavisAccess

NavisAccess™ is a powerful new SNMP network management application from Ascend that can be used to manage not only Ascend equipment, but also other SNMP-manageable devices in an ISP, carrier or corporate WAN network. NavisAccess comes with an array of common MIBs for immediate compilation and use in management of most common routers and switches on a WAN network. Additionally, full GUI management tools are included (including active backpanel views) for the Cisco 2000, 3000, 4000 and 7000 series of routers.

NavisAccess' key benefits to Ascend customers are:

1. Comprehensive management support of all Ascend access switches
2. Integrated support for third-party SNMP devices such as non-Ascend routers, switches and hubs
3. Network access lines and interface management (e.g., T1/E1, T3, ISDN, xDSL etc.)
4. Management of network services such as Frame Relay, ISDN and ATM
5. Management of elements by grouping into logical entities
6. Individual DSL line level management for DSL TNT

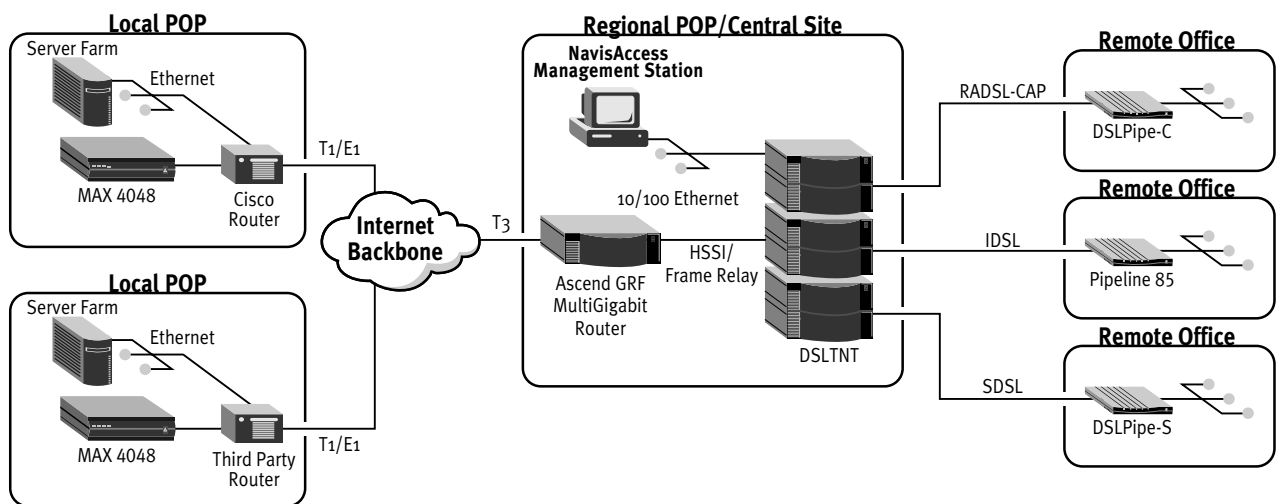


Figure 19 – Use NavisAccess to manage your Ascend and third party WAN equipment.

NavisAccess has been designed to support the most popular management platforms and operating systems. NavisAccess is available as a fully integrated application that runs under HP OpenView 4.1 on Solaris 2.5 and HP OpenView 4.1 on HP UX 10.0 and NavisAccess is also available as a standalone application that runs on UNIX (Solaris) or NT workstations.

Craft Port

A VT100 (or a PC running a VT100 terminal emulation program) can be used to control the DSLTNT. The windowed user interface displays all functions and status screens and can be used to control remote DSLTNTs.

The DSLTNT craft interface provides the following administrative features:

Security Profiles – The DSLTNT has password security to protect the box itself from unauthorized access.

System administration commands – The DSLTNT provides commands for rebooting the device, saving or restoring configuration information, and performing other administrative functions. The DSLTNT enables software upgrades in the field without opening the unit or changing memory chips, a process that also makes use of the configuration management commands.

“DO” commands – Pressing Ctrl-D in the craft interface displays the “DO” menu, which contains commands for changing security levels in the DSLTNT, or manually dialing or clearing a call. When full access (or another appropriate security level) has been activated, you can perform all DO commands as well as other administrative operations.

Terminal server command-line interface – The DSLTNT’s Command-Line Interface (CLI) provides commands for testing a connection, checking routing tables and other configuration parameters, or configuring far-end Ascend units across the WAN. Many of these commands are related to system administration.

MIF interface – Machine Interface Format (MIF) is an Ascend-specific scripting language that provides an alternative configuration interface for Ascend units. You can use a command-line or write a MIF program that sets Ascend parameters rather than use the configuration menus to change one parameter after another. MIF programs provide a batch-processing method of changing a configuration or performing a series of actions. You can also use MIF to program asynchronous traps to capture Call Detail Reporting (CDR) data, which otherwise records call events in the order in which they occur in real-time without saving the data.

Status windows – The status windows in the craft interface provide information about what is currently happening in the DSLTNT. For example, one status window displays up to 31 of the most recent system events that have occurred since the DSLTNT was powered up, and another displays statistics about the currently active session. You can also perform DO commands, for example, clear an active connection, using the status windows.

Interaction with syslog for ASCII log files – If a Windows or UNIX host on the local network is running the Syslog daemon, you can configure the DSLTNT to write log messages to an ASCII file on that host.

SNMP Management

The DSLTNT completely supports the SNMP management standard for all its management functions; every command that you can manipulate via the Telnet interface can also be managed via SNMP commands. By implementing standard and enterprise SNMP MIBs within the DSLTNT, Ascend provides the ability to manage DSLTNTs along with your other SNMP devices from a central generic SNMP management platform (for example NavisAccess by Ascend, SUN Microsystem’s SunNet Manager, Cabletron’s Spectrum, or HP OpenView).

DSLNT systems support SNMP MIB II, the T1 MIB, and the Ascend Enterprise MIB. Ascend’s SNMP implementation also supports SNMP traps, allowing DSLTNT units to send alarms, call detail reporting, and other management information directly to an SNMP management station without being polled.

Ascend’s SNMP management feature allows true integration of DSLTNT units into the ISP internetwork, by providing the means to manage the Ascend equipment as easily as any other bridge, router, or other SNMP-managed equipment on the network.

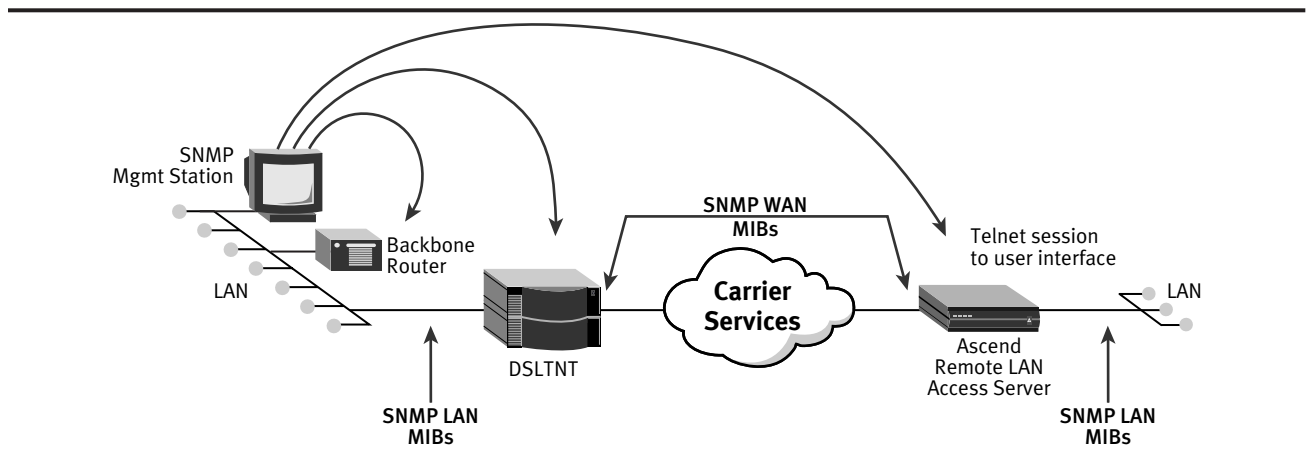


Figure 20 – SNMP management

TCP/Telnet Management

Ascend DSLTNTs can be remotely managed by establishing a Telnet session to the remote unit from any Telnet workstation on the network and viewing the DSLTNT user interface on a Telnet VT100 window. A network administrator at a management station connected to the Internet (or LAN) can use this feature to manage the DSLTNT from a local or remote computer. You can also use it to manage remote Ascend units, such as DSLPipes, at a remote office or home office. From a Telnet session you can perform all of the configuration, diagnostic, management, and other functions that could be performed from a computer directly connected to the DSLTNT or Pipeline Control port.

FLASH Memory/Remote Software Upgrades

All Ascend DSLTNTs are based on FLASH EEPROM technology. The FLASH EEPROM provides the ability to perform software upgrades in the field without opening the unit or changing memory chips.

All DSLTNTs may be upgraded through the serial control port of the unit. This can be performed locally or through the dial-in modem. Note that remote software upgrades cannot be performed over the WAN interface due to the conflict between running the WAN and reprogramming the software.

Annex D Frame Relay Link Monitoring

The Ascend DSLTNT supports the Frame Relay ANSI Annex D link management specification (RFC 1490) for status monitoring of Frame Relay links. Specifically supported is the specification for ANSI T1.617/Annex D (and the corresponding CCITT Q.933/Annex A) for Local Management Interface as well as LEI Revision 1. This feature helps network managers understand the detailed performance and usage characteristics of a company's Frame Relay network.

From the viewpoint of the DSLTNT, a Frame Relay switch is an endpoint for all DLCIs (Data Link Connection Indicators) connecting to it. A DLCI identifies a Connection Profile as a logical link. The Frame Relay concentrator connects the endpoints of the DLCIs to each other to make a virtual permanent circuit to which users can connect. The circuit acts like a wire between two endpoints with a fixed maximum bandwidth (though this may be flexible in the case of the Frame Relay link).

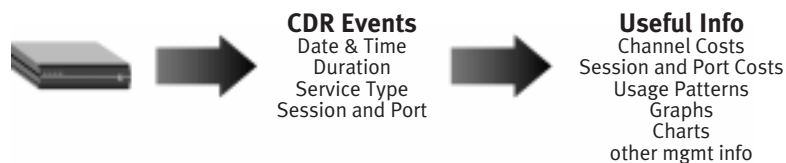
Annex D specifies the link management protocol used between the DSLTNT and the Frame Relay switch on the backbone to which the DSLTNT Frame Relay circuit is terminated. The Annex D standard specifies the procedures for user-network signaling for ISDN support of Frame Relay calls. You can display Link Management Information (LMI) for each link activated by a Frame Relay switch. (Please refer to the Annex D specification for a full definition of each of the fields reported.)

Call Detail Reporting

Telephone Companies (ILEC) and CLECs frequently need detailed information on usage of their networks. Most DSL subscribers access the Internet, and the service providers require detailed information about bandwidth usage patterns for billing and planning purposes. Corporate MIS departments frequently need very similar information for allocation of expenses to the departments. Because users may be billed by the network carrier for bandwidth on an as-used basis, information that helps understand and manage their bandwidth usage is invaluable.

This information can then be manipulated to create a wide range of different reports, including individual connection costs (to be compared to carrier's billing data), inverse multiplexer-based WAN session costs, costs on an application-by-application basis, bandwidth usage patterns over specified time periods, and so on. Such information can be used to better understand bandwidth usage and, if necessary, make adjustments between network sites. Even more call reporting detail features are available with the Ascend Access Control™ RADIUS server software which provides an interface to ODBC compliant databases.

The DSLTNT includes the ability to specify a usage cap over a specified time period. This helps preclude unexpectedly large monthly bills.



**Provides necessary information for
comprehensive network management**

Example:

Actual and Total Connections vs. Time

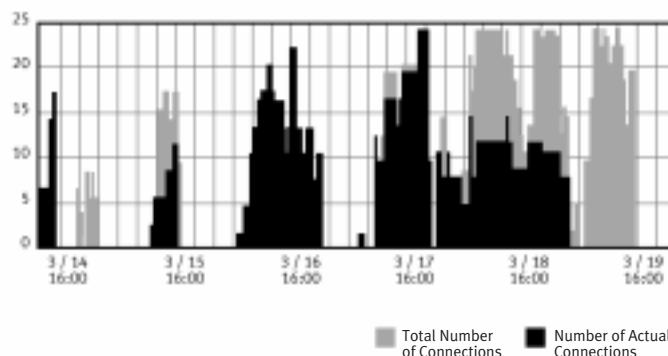


Figure 21 – CDR provides the information you need to manage your bandwidth expenses.

6. DSLNT Security

The DSLNT provides full WAN security through direct password, and secured password exchange. The security is achieved through a combination of the PPP-based security standards and Ascend WAN security extensions.

PPP provides two levels of authentication security: Password Authentication Protocol (PAP) and Challenge-Handshake Authentication Protocol (CHAP). Both of these are supported by the DSLNT.

PAP: Password Authentication Protocol

PAP provides a simple method for a peer to establish its identity in a 2-way handshake. This is done only upon initial link establishment, and “in the clear.” PAP is not a particularly strong authentication method, although it does provide for baseline security when interoperating with non-Ascend equipment, and is frequently enough security for basic Internet access services.

CHAP and MS-CHAP: Challenge-Handshake Authentication Protocol

CHAP is used to periodically verify the identity of a peer using a three-way handshake. This is done upon initial link establishment, and may be repeated anytime after the link has been established.

CHAP is encrypted using a one-way hash function. CHAP provides protection against playback attack through the use of an incrementally changing identifier and a variable challenge value. The use of repeated challenges is intended to limit the time of exposure to any single attack. The DSLNT controls the frequency and timing of the challenges.

Support for the Microsoft – Challenge Handshake Authentication Protocol (MS-CHAP) format supported by Windows NT systems has also been added to the DSLNT.

Security Servers

As large communities of users are signed-up, it becomes impractical to store all relevant security and access parameters in a single piece of equipment. It is instead preferable to set up a host application database that maintains current user lists, passwords, and permissions. This database is then accessed by a DSLNT when users attempt to connect, on an on-demand as-needed basis. Thus one database serves many potential users and DSLNT switches, and security management may be more effectively audited and controlled. This one database typically provides all necessary data for user authentication, authorization and accounting.

To make this possible, the DSLNT systems communicate with the security databases by a real-time protocol, specifically RADIUS, TACACS or TACACS+.

RADIUS Security Servers

Remote Access Dial In User Server (RADIUS) is a more robust protocol that can provide greater flexibility than TACACS. In a RADIUS query, the DSLNT systems provide the user ID and password to the server, and in return receive a complete profile, which supplies connection details about the user (see Figure 22).

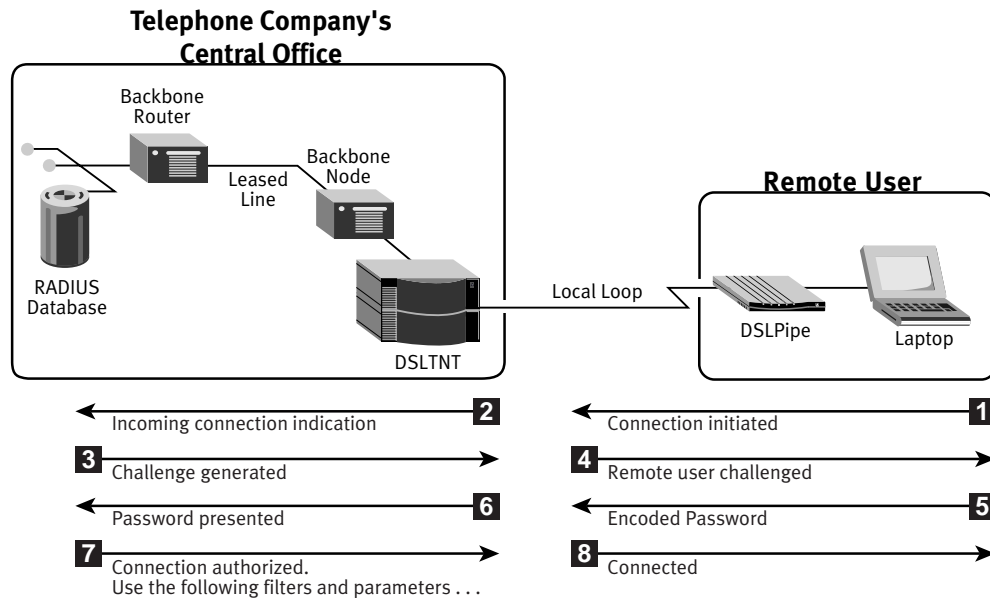


Figure 22 – A RADIUS access query.

Multi-level User-access Password Security

The DSLTNT provides multi-level password security to allow different levels of access to different users. Access security for DSLTNT is defined by what are called “Security Profiles”. Security Profiles are the means by which access to crucial DSLTNT operations is limited, while leaving other less critical operations more broadly available.

Encrypted Token Card

The DSLTNT supports hand-held personal security cards, such as those provided by Security Dynamics and Secure Computing’s Enigma Logic division. These cards have dynamic passwords that provide a higher level of security than traditional static password methods. Support for dynamic passwords requires the use of a RADIUS server that has access to an authentication server, such as an Security Dynamics ACE or Enigma Logic SafeWord AS authentication server.

Logging

The DSLTNT supports two important tools for logging information on the activity of your DSLTNT to help monitor and ensure high levels of security; Syslog and RADIUS.

Syslog is an IP protocol that sends system status messages to a host computer, known as the syslog host. This host is specified by the Log Host parameter in the Ethernet Profile. The log host saves the system status messages in a syslog file. These messages are derived from two sources-the Message Log display and the CDR display. See the UNIX man pages on `logger(1)`, `syslog(3)`, `syslog.conf(5)`, and `syslogd(8)` for details on the syslog daemon.

The DSLTNT can be configured to send detailed warning, notice, and CDR records from the system logs to the Syslog host. CDR is a feature that provides a database of information about each call, including date, time, duration, called number, calling number, call direction, service type, and associated inverse multiplexing session and port. Alarms and detailed access information can therefore be tracked to monitor any potential breach of security.

RADIUS servers, as mentioned above, are powerful authentication, authorization and accounting databases that can also log detailed information to enhance your understanding of any efforts to breach your network’s security. DSLTNT supports both the public domain version of RADIUS which is available from the Ascend FTP server, as well as the sophisticated Ascend Access Control RADIUS server that is sold by Ascend. Detailed information on both these servers is available on the Ascend web site.

Telnet Password Verification Failure Trap

This feature adds the IP address of the Telnet client to the existing security violation message indicating the maximum number of Telnet login attempts to a DSLTNT has been exceeded.

Static Packet Filtering

The DSLTNT provides standard packet filtering mechanisms that enables you to set up basic levels of security in your networking environment. You can define filters that will exclude certain packets from reaching your network or from going out to the WAN.

Each filter consists of an ordered list of conditions based on either IP-specific or protocol-independent information. For an IP filter, you can filter data based on addresses, protocols, port numbers, and other packet conditions. For a generic filter, you can specify data values within packets.

Properly incorporating and using filtering provides enhanced security. The filtering within the DSLTNT allows for independent filters on a per-interface and per-connection for:

- Connection establishment
- Connection clearing (idle timer filter)
- Transmit data
- Receive data

Each filter associated with an interface consists of an ordered list of allow/deny parameters based on IP-specific or protocol-independent parameters. For IP specific filters, any combination of:

- Source/destination address
- Protocol discriminator
- Source/destination port
- Established/Not Established TCP sessions

For protocol independent filters, any combination of data comparisons and masks may be used to allow/deny packet traffic.

Dynamic Firewall – SecureConnect

Ascend SecureConnect™ Firewall is a software option that provides firewall security protection to ISP networks, corporate LANs, remote offices, and telecommuters. SecureConnect Firewall offers a fully integrated, single-vendor dynamic firewall solution that cost-effectively protects a company's entire network against intruders.

Virtual Private Networks, Tunneling and Mobile Nodes

The DSLTNT's extensive protocol support and Access Control RADIUS software allow carriers and CLECs to offer businesses a multi-protocol Virtual Private Network (VPN) over the Internet by using tunneling protocols such as Point to Point Tunneling Protocol (PPTP) and Ascend Tunnel Management Protocol (ATMP). VPNs use these secure tunneling protocols and the Internet to replace expensive leased lines and Frame Relay networks that companies have traditionally used to interconnect branch offices and corporate sites.

These VPNs enable corporate clients to reduce long-distance charges, to eliminate mesh networks, and to out-source the management and security responsibilities of maintaining private WANs. Through the use of VPNs companies can achieve savings up to 60% over traditional private networks. To take advantage of the this market for VPNs, carriers must select equipment and RADIUS servers that support tunneling, as well as authentication and encryption.

Ascend provides the following features for secure VPNs:

- PPTP and ATMP tunneling are available today, and Ascend is committed to supporting L2TP (Layer-2 Tunneling Protocol) soon after the standard is finalized.
- Access Control's Extended RADIUS capabilities for support of Proxy RADIUS, and necessary tunneling protocols
- Remotely manageable perimeter firewall security

In addition to the basic technologies necessary to implement VPNs, Ascend has integrated a number of important performance enhancements that provide maximized bandwidth utilization. These enhancements include:

- IP Multicast support for multi-point data broadcast applications
- Frame Relay Direct to channel tunnels through virtual circuits in the carrier's Frame Relay backbone.
- Bandwidth-on-demand with the Multilink Protocol (MP) and the Multilink Protocol Plus™ (MP+)

Tunneling encapsulates IP, IPX, AppleTalk, NetBIOS, and NetBEUI packets within IP packets for transmission over the Internet. At the receiving end, the encapsulation is removed, leaving the original packets intact. This process is automatic and transparent to users. As shown in Figure 25, tunneling ensures the privacy of data packets while they traverse a public network.

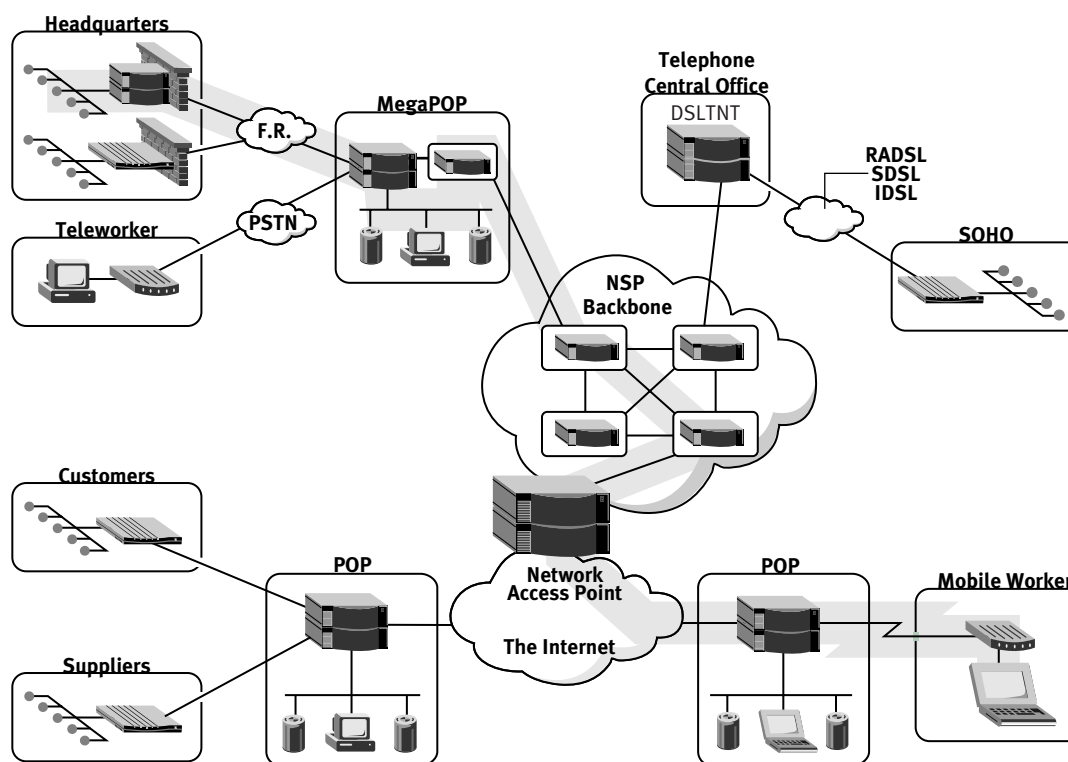


Figure 23 – Tunneling keeps data private on a public network.

Ascend uses its own ATMP for tunneling from one DSLTNT to another within the carrier network. This protocol dynamically manages Generic Routing Encapsulation (GRE) protocol tunnels over the Internet. ATMP has the ability to route Novell IPX and private IP packets over the Internet. Some advantages of ATMP over other tunnel protocols include:

- Multiprotocol support (IP, IPX, and AppleTalk)
- Simple to use
- Uses the standard GRE protocol (RFC 1701)

ATMP is a UDP/IP-based protocol that provides a cross-Internet tunneling mechanism using standard GRE between two Ascend units.

The secure “tunnel” has a DSLTNT unit at each end. The mobile user connects to a remote DSLTNT through a PPP session. At the other end of the tunnel is an DSLTNT assigned to the home network. Each DSLTNT tracks the location information of the node and encapsulates packets for transmission to and from the node. The DSLTNT at the home network can forward the packet to a pre-determined WAN connection. To ensure the proper security, a RADIUS database server must be present. The home DSLTNT requires password authentication through the Message Digest (MD5) algorithm before it accepts a tunnel connection.

ATMP tunnels enable a mobile node to access a home network through two Ascend devices – a foreign agent and a home agent – across the Internet. If the home network is an IP network ATMP can enable LAN-to-LAN connectivity through the tunnel.

Ascend also supports the Point-to-Point Tunneling Protocol (PPTP), which was developed by Microsoft and Ascend and is available with the Microsoft NT RAS 4.0 operating system. PPTP requires that a Windows NT server be present as the termination point of the tunnel on the customer’s LAN. By contrast, ATMP is platform-independent and lets the originating caller engage in a session with any TCP/IP or IPX server. PPTP can route IP, IPX, NetBIOS, and NetBEUI packets.

7. DSLNTNT Diagnostics

Power-on Self-tests

When turned on, the DSLNTNT runs a complete set of diagnostic tests. If a problem is observed, it will notify the user through the terminal interface or alternatively by blinking an error code using its front panel LEDs.

Continuous Statistics Collection

The DSLNTNT collects statistics concerning connections: number of transmitted and received packets, error conditions, and so on. These statistics are kept in memory, available for retrieval from a local or remote management station.

Line Loopback

The Line Loopback test permits network administrators to send a block of data to the remote CPE and verify the integrity and quality of the local loop.

Corrupt CRC Test

This test can generate CRC errors from the CO to the remote CPE and verify that the remote CPE can detect CRC errors.

Request Corrupt CRC Test

This test sends a message from the COE to the remote CPE, requesting the remote CPE to send CRC errors so the COE can detect the errors.

Monitoring

The IDSL cards facilitates in detecting and reporting errors at the COE. These statistics include Line Errors, Block Errors, Near End Block Errors (NEBE) and Far End Block Errors (FEBE).

Real Time Signal Quality

Real Time Signal Quality measures signal strength and line quality, allowing network managers to pinpoint any copper related problems.

Out of Service Command

This command lets network managers take a line out of service for diagnostic purposes. Lines may be placed back in service by issuing a corresponding command.

WAN Encapsulation Protocols

The DSLNTNT is compatible with a long list of WAN encapsulation protocols including: PPP, MP, MP+, BACP, X.25 encapsulation, Frame Relay encapsulation (RFC 1490) and Combinet encapsulation. Virtual Private Networking (VPN) encapsulation protocols include PPTP, ATMP and GRE, with L2TP shortly after the standard is finalized. ARA and TCP-CLEAR are also supported.

PPP

The Point to Point Protocol (PPP) is the standard wide area network protocol for interoperability of routers and bridges today. PPP is also supported in workstations and personal computers, allowing direct DSL access from a single computer to a corporate or public Internet. PPP is a constantly growing and evolving standard supporting new capabilities. Newer capabilities in PPP include Compression Control Protocol (CCP) to support standard and negotiated payload compression. The DSLNTNT supports all of PPP's optional features, including all security header compression and payload compression features. On a per-interface basis, you may enable or disable any of the optional features.

MP, MP+ and BACP

The DSLNT product line offers complete support for the MP and MP+ connections, which use PPP encapsulation and support up to 30 inverse multiplexed, multi-channel connections. Standard PPP calls use only a single channel, so the key benefit of MP+ is dynamically allocated increased bandwidth when traffic levels dictate such a need. MP+ calls are typically network-to-network connections involving an IP, IPX, or other type of networking connection. BACP offers much the same functionality of MP+ but in an Internet-standard configuration for compatibility with third-party equipment.

Frame Relay RFC 1490

The DSLNT provides for encapsulation as defined in RFC 1490 over Frame Relay links. This means that a Frame Relay PVC may be provisioned between the DSLNT and another node and the DSLNT will encapsulate data for transmission over the connection using RFC 1490 encapsulation.

ATMP, GRE and PPTP

The DSLNT product line fully supports GRE tunneling, PPTP, and ATMP. ATMP is a UDP/IP-based protocol that provides a cross-Internet tunneling mechanism using standard GRE between two Ascend products. GRE is a protocol for encapsulation of one network layer protocol over another network layer protocol and is described in RFC 1701. The encapsulation provides secure transmission of packet contents and enables transmission of packets that would otherwise be unacceptable on the Internet, such as IP packets that use unregistered addresses or IPX packets from roaming clients.

Ascend has its own tunnel management protocol (ATMP) that creates and tears down the tunnel between two Ascend units. In effect, the tunnel collapses the Internet cloud and provides what looks like direct access to a home network. Packets received through the tunnel must be multiplexed within the DSLNT, so ATMP applies only to IP, IPX or AppleTalk networks at this time.

ARA

AppleTalk Remote Access (ARA) connects a Macintosh to an AppleTalk or TCP/IP network over an asynchronous modem. ARA provides its own authentication method, as well as a maximum ARA connection time. If the ARA encapsulates IP packets, IP multiplexing is supported. ARA connections are single-channel connections. Ascend's AppleTalk implementation includes support for ARA dial-in access for ARA 1.0 and 2.0.

Other WAN Protocols

G.703/G.732 Framing (E1)

An E1 line consists of 32 64 Kbps channels with a total throughput of 2.048 Mbps. It uses 30 B-channels for user data, one 64 Kbps D-channel for ISDN signaling, and one framing channel. This type of communications line is a standard in Europe and Asia called CEPT G.703/G.704. R2 signaling is also supported.

Switch types

The network switch that provides an E1/PRI line to DSLNT and connects the line to the WAN can be any one of the following:

- Net 5 (the default)

Net 5 is the switch type for European ISDN services in Belgium, Netherlands, Switzerland, Sweden, Denmark, and Singapore.

- DASS 2

DASS 2 is available for installations in the U.K. only.

- ISDX
- ISLX
- MERCURY

ISDX, ISLX, and MERCURY are varieties of DPNSS.

- Australian
- NTI (Northern Telecom, Inc.)
- French (VN3 ISDN PRI)
- German (1TR6)

Framing mode

The physical layer can use one of the following methods of framing data:

- G.703 (a standard framing mode used by most E1 ISDN providers and by DASS 2).
- 2DS (a variant of G.703 required by most E1 DPNSS providers in the U.K).

Appendix One: DSLTNT Line Cards

The DSLTNT has an array of expansion modules that allow you to customize your system with the features and benefits you need, when you need them. After you've got your initial system configured, you can easily upgrade your system with additional expansion modules that plug into your existing chassis, or into additional DSLTNT expansion chassis' that can be integrated seamlessly using the DSLTNT intra-shelf expansion bus.

While each DSLTNT expansion module provides unique features and benefits, they have been designed with several common design approaches that help to maximize overall system performance and reliability:

High-performance RISC CPU – Every expansion module incorporates a high-performance Intel i960 RISC processor that allows for distributed processing and scalable processing power as the system is filled with modules. In addition to the high performance CPU, there is significant DRAM on each module to allow for significant route caches, and ongoing enhancement of the feature set of the existing software that runs on each module.

Distributed Processing – Utilizing the high speed CPU, every module performs “Front-end Processing” of as much data as possible. For example, encapsulation processing of all data is handled as close to the physical line termination as possible. Additionally, each module does its own Caching and Call Processing thereby minimizing any impact on the shelf controller CPU and maximizing the scalability of the DSLTNT system.

Dual-port RAM – Each expansion module incorporates high-speed dual port RAM that allows simultaneous read/write commands directly between the shelf controller memory and the Expansion module CPU's memory. The dual-port RAM creates the interface for the control bus over which the Shelf Controller maintains constant communications with each of the expansion cards, and the cards with each other.

Cell-bus Interface – Each expansion bus incorporates a Cell bus interface for direct multiplexing of data to other expansion modules, or to the shelf controller. Every expansion module incorporates the SAR interface circuitry that assembles or reassembles the data for transfer across the cell bus.

Steel Enclosure – The expansion module circuit boards are encased in a protective steel enclosure for maximum protection against physical shock, and isolation from electrical interference. Every expansion module is designed to comply with the rigorous NEBS (National Electronics Building Standards) Level-3 of certification for Telephone company central office use.

Shelf Controller

The DSLTNT was designed with the goal of merging the best elements of a distributed processing system and a centralized processing system so as to get the optimal balance of reliability, scalability and cost-effectiveness. Toward this aim the DSLTNT was designed with a shelf controller module that resides in each DSLTNT shelf that can provide the centralized management, communications, synchronization and multiplexing functions for the entire system. The shelf controllers in the other shelves of a DSLTNT system are always sharing information and are available in hot-standby mode should the designated master shelf controller ever encounter problems.

The key components of the Shelf Controller are:

CPU – The shelf controller uses a high performance Intel RISC i960 Processor

Cell Switches – Three cell concentrators per shelf controller, for swift transfer of data over the intershell and intrashelf buses for maximum performance. Each Cell concentrator has three ports – dual transmit and receive paths – so you can get data into the concentrator and out of the concentrator at the same time. The third port on the ATM switch goes to the Intershell link.

SAR IC – provide the Segmentation And Reassembly (SAR) of the data sent over the cell bus

TAXI IC – The TAXI (Transparent Asynchronous Xmitter-Receiver Interface) integrated circuit drives the intershell bus. Intershell Bus – The Intershell bus is a physical and logical ring; the cabling must form a closed loop using the shelf controller Intershell bus ports.

DRAM – The shelf controller has 8Mb of standard DRAM for the routing table and the shelf controller's executable code that handles the assignment of TDM channels and the over all chassis housekeeping of data structures. This memory can be upgraded at any time with the addition of DRAM using the DRAM/JEDEC (Joint Electron Device Engineering Council) expansion slot which allows up to 32Mb of additional DRAM to be added. Significant new software releases such as for BGP4 support and larger OSPF routing areas will require additional DRAM in the shelf controller. The DSLTNT administrator can query the DSLTNT via CLI (command line interface) commands and SNMP queries for information on system resource utilization.

On-Board FLASH – where store compressed executable code for upgrade. Decompresses code out to DRAM. Motherboard's executable code is decompressed into mother board DRAM from FLASH. There is enough memory space on the board that the software can be decompressed and verified as operative before the active software is erased.

PC Card Slots – Each shelf controller has one Type III, or two type II PC Card slots (previously called PCMCIA card slots). These PC card slots can be used for additional FLASH memory cards that will be needed for the BGP4 code, and larger OSPF areas.

10Base-T/100Base-T Ethernet port – Provide basic network connectivity for the DSLTNT shelf.

Serial RS232 Port – Provides direct terminal or PC access to the shelf controller, or can be used to connect a modem for dial-up access to DSLTNT.

Shelf Controller ID – Factory set at "1," must be set to a unique number within at DSLTNT system group.

Alarm Relay – The DSLTNT is equipped with an alarm relay whose contacts are brought out on the back panel's alarm relay terminal block. The alarm relay contacts close during loss of power, during hardware failure, or whenever the DSLTNT is being reset, such as during its power-on self test. During normal operation, the alarm relay contacts remain open.

Ascend's MultiDSL Line Cards

Unlike other vendors of xDSL equipment that require you to purchase an entirely new hardware and management system, and add yet another layer of complexity to your network, Ascend allows you to seamlessly integrate xDSL technologies into your existing DSLTNT access solution to provide a complete and compact, manageable, and familiar operating environment. The DSLTNT's MultiDSL line cards support allows you to upgrade incrementally with only the card density that you need, when you need it. With the DSLTNT these new access technologies are just one more line card option and there is no new learning curve that your NOC needs to learn how to support; if you are familiar with the Ascend products already then implementation and support of xDSL line cards will be simple and quick.

Every xDSL line card leverages off the Ascend core operating system that is currently used in most of the top 30 Internet service providers.

As everyone who runs a network knows, the upfront equipment costs are only a small part of the total cost of a network. Ongoing support, maintenance and line costs can quickly exceed the original investment and become the majority of the network expenditure. Ascend has focused on minimizing the total cost of ownership by providing a complete platform for both the hardware and management software so that when you buy an Ascend product you are getting an important part of an integrated solution. By comparison, most other vendors will sell just one piece of a puzzle; forcing the bulk of the integration and management costs onto you and quickly eliminating any potential savings that may have been expected.

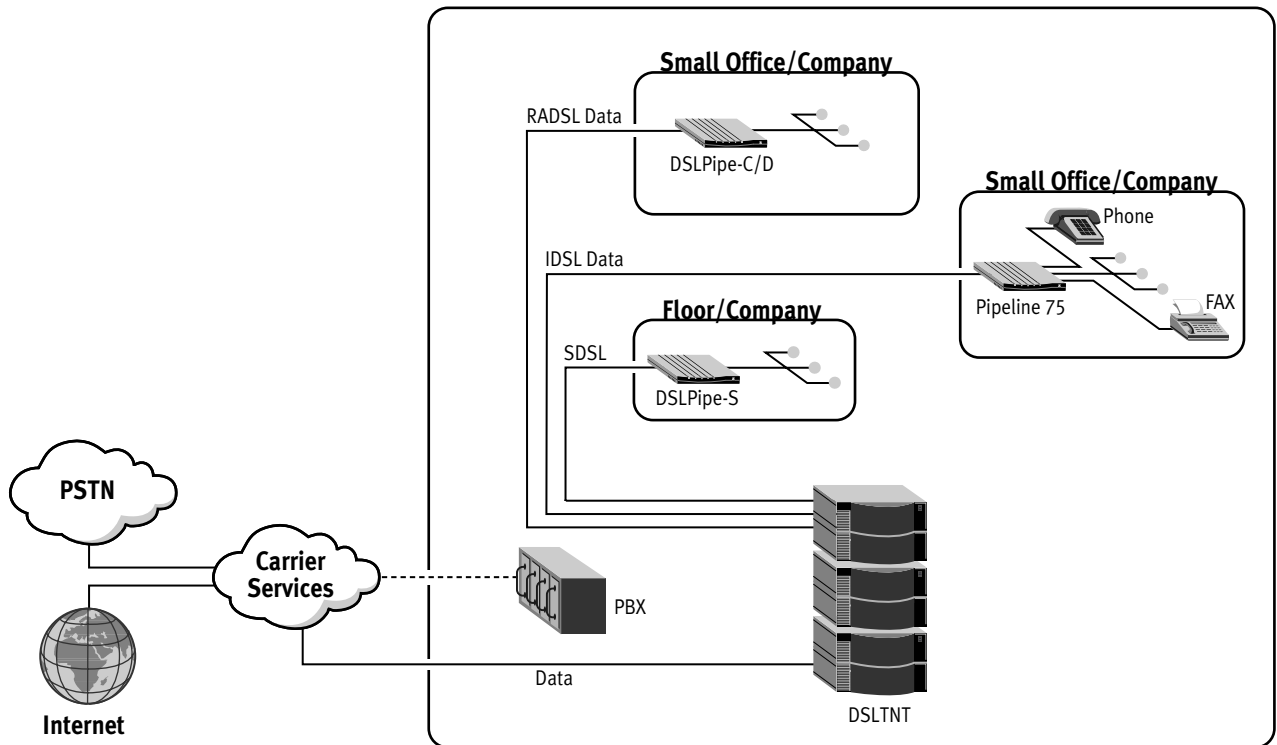


Figure 24 – Office tower/corporate campus application example

Benefits of the Ascend approach with MultiDSL:

- Leverages proven remote access technology and expertise from Ascend
- ISPs/Carriers/CAPs can immediately enter the DSL market with IDSL
- IDSL alleviates the PSTN network congestion
- Multi-service platform provides smooth migration (IDSL, SDSL, RADSL-CAP, RADSL-DMT)
- Ascend has end-to-end CPE and COE products for turn-key solution
- Delivers high-speed remote access for corporate customers
- Comprehensive support for network management, User and Accounting
- Virtual Private Network Support – PPTP, ATMP, Frame Relay and IP Direct – L2TP shortly after standards are agreed to

IDSL Module

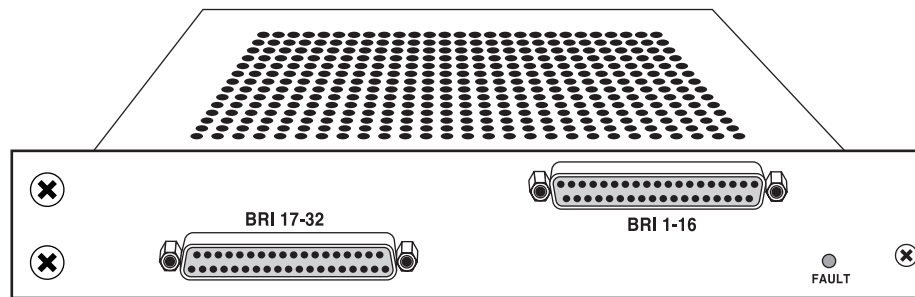


Figure 25 – IDSL module

The IDSL line card has thirty two (32) IDSL ports and is ideal for moderate to low speed data access to a central network or the Internet. IDSL supports a 128 Kbps full-time data circuit and avoids the common problem of losing valuable central office switched circuits to long data connections. Voice support for the IDSL module will be a software-only upgrade available in the future. IDSL is an Ascend innovation that provides simple high-speed data networking over a local loop of up to 18,000 ft. In IDSL installations the DSLTNT is installed in central office sites and directly terminates the IDSL data circuit – by-passing the switched telephone network.

IDSL is fully compatible with any standard ISDN BRI Terminal Adapter, Bridge or Router which means that customers and users can easily upgrade to this service with a minimal of hassle. The IDSL line accepts the standard AT&T 5ESS “data-only” configuration parameters that are commonly supported in ISDN data equipment and can be in the same binder group as any other standard T1, SDSL or RDSL lines.

The IDSL line card supports standard 2B1Q line encoding for transparent operation through “U” loop repeaters and Digital Loop Carrier systems (DLCs). HDLC controllers are built into the IDSL line card eliminating the need for any additional HDLC processing of the incoming IDSL data. IDSL line cards are simple to operate, easy to install, and provide a cost-effective alternative to switched or leased 56 Kbps line as well as full-time ISDN circuits.

The IDSL line card is a dual-slot card and up to 3 of them can be used in any DSLTNT shelf, for a total of 224 IDSL ports in any DSLTNT shelf. The IDSL line card is ideal for low to moderate bit-rate applications that require full-time connectivity; some typical application scenarios would be Internet links for small- to medium-sized businesses that want to host a web site in their corporate office and also use the full-time Internet connectivity for employee Internet access.

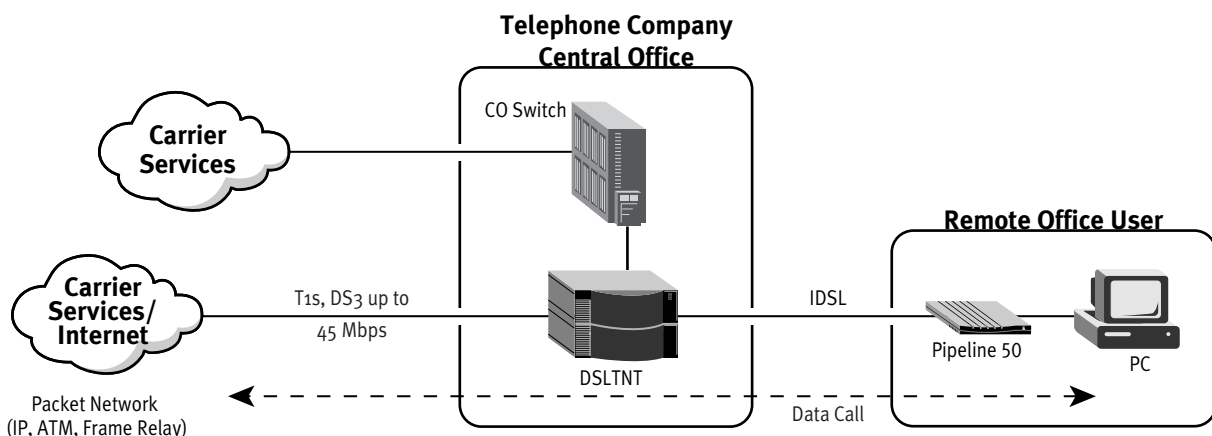


Figure 26 – End-to-end connectivity using IDSL

Module Summary

Module Type	IDSL
Module Model Number/Serial Number	TNT-SL-IDSL
DSLNT Slots Occupied	Two
Transfer Rate	128 Kbps symmetric data service
Transmission Distance	18,000 ft.
Data/Voice Support	Data available now, Voice support to be a software upgrade in future
Module Weight	Approx. 5.6 lbs (2.55 kg)
Module Dimensions	8.8 in high x 10.6 in long (22.35 cm x 26.92 cm)
Hot-swap Capability	Yes
Operating Temperature	32° to 104° F (0° to 40° C)
Operating Humidity	10% to 90%, non-condensing
CPU Type/Speed	Intel i960 RISC CPU
Interfaces per Card	2 DB37 connectors, each providing 16 IDSL sessions for a total of 32 (DB37 to 50-pin telco pigtail cables included)
Connectors	Must meet JIS C 5973 standards
Max. Number of modules per Shelf	7
Max. Number of modules per System*	21
Protocols Supported	PPP, MP, MP+, Frame Relay
Switch Configuration	AT&T Point to Point
Line Signaling Support	2B1Q
Compatibility	Compatible with any standard ISDN BRI CPE (ISDN TA/Modem, Bridge or Router), Transparent operation through U-loop repeaters.

**A system can be made up of up to 3 shelves. A single DSLTNT chassis is referred to as a shelf.*

SDSL Module

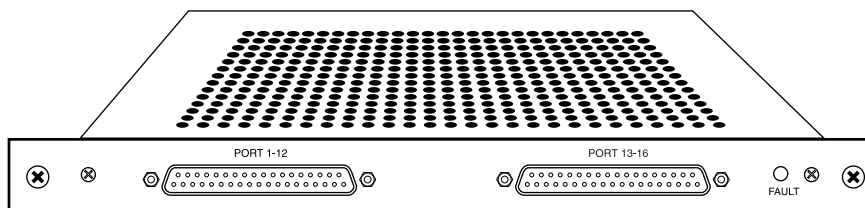


Figure 27 – SDSL module

The Single-pair high-speed Digital Subscriber Line (SDSL) line card has 16 interfaces via two connectors and is ideal for moderate to high-speed corporate data network or Internet connectivity. SDSL supports up to 768 Kbps symmetric data rate, on a single pair for up to 12,000 feet.

Ascend's SDSL solution offers standard 2B1Q line encoding, integrated line monitoring and diagnostics, and integrates smoothly with the Ascend DSLPipe-S CPE router that functions just as the current Ascend Pipeline routers but with the addition of an SDSL interface. Just as with the Pipeline ISDN routers, the DSLPipe-S router incorporates IP, IPX and AppleTalk routing and a standard Ethernet interface for LAN connectivity.

Up to 15 SDSL cards can be supported in any one DSLTNT shelf, for a total of 240 ports per DSLTNT shelf. The SDSL circuit is a simple process to configure, with no user-configurable parameters at the CPE equipment, and the SDSL line can be in the same binder group as any other standard T1, SDSL or RADSL lines.

This MultiDSL line card was designed to high-speed corporate network or Internet access to any company or individual requiring full-time data services. It is a cost-effective alternative to traditional T1 services or lower speed switched services.

With the DSLPipe-2S as the customer premises equipment, service providers may combine 2 SDSL lines and bond them together using MP or MP+ to offer 1-54 Mbps access symmetric data rate on two pairs of wires for up to 12,000 feet.

Module Summary

Module Type	SDSL
Module Model Number/Part Number	TNT-SL-SDSL
DSLNT Slots Occupied	One
Transfer Rate	768 Kbps or 1.54 Mbps symmetric data service
Transmission Distance	12,000 ft. (3.7 km)
Connector Requirements	DB37 connector, providing 16 SDSL sessions (DB37 to 50-pin telco pigtail cable included)
Module Weight	Approx. 3.9 lbs (1.77 kg)
Module Dimensions	8.8 in high x 10.6 in long (22.35 cm x 26.92 cm)
Hot-swap Capability	Yes
Operating Temperature	32° to 104° F (0° to 40° C)
Operating Humidity	10% to 90%, non-condensing
CPU Type/Speed	Intel i960 RISC CPU
Interfaces per Card	16
Max. Number of modules per Shelf	15
Max. Number of modules per System*	45
Line Encoding	2B1Q
Protocols Supported	PPP, Frame Relay, MP, MP+
CPE Compatibility	Ascend DSLPipe-S, DSLPipe-2S
Other	Pigtail cables included with module

**A system can be made up of up to 3 shelves. A single DSLTNT chassis is referred to as a shelf.*

RADSL Module (Rate Adaptive DSL)

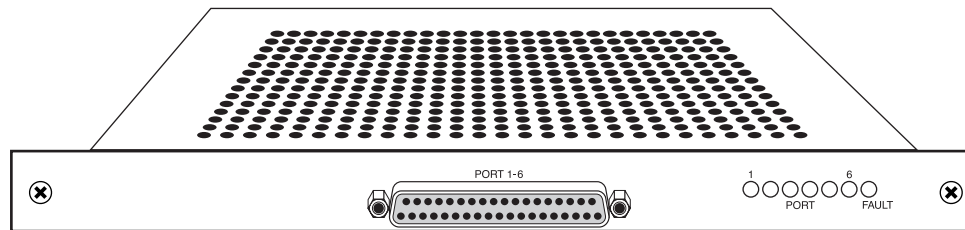


Figure 28 – RADSL module

RADSL-CAP

The DSLTNT RADSL-CAP module has 6 RADSL interfaces that supports up to 7 Mbps downstream and 1 Mbps upstream up to 10,000 ft from the central office, and 640 Kbps downstream and 544 Kbps upstream up to 18,000 ft. from the central office. The Ascend RADSL-CAP solution is designed for full-time data connectivity as well as life-line POTS support, and the DSLPipe-C router that acts as CPE equipment.

Rate Adaptive Digital Subscriber Line (RADSL) allows the DSLTNT to detect the noise level on the line and automatically adjust the data transfer rate for optimum performance.

Up to 15 RADSL-CAP modules can be used in a DSLTNT shelf, and up to 45 modules in a three-shelf DSLTNT system for a total of up to 90 ports of RADSL-CAP connectivity per DSLTNT shelf.

The RADSL line card was designed for high-speed corporate network or Internet access for an individual requiring high-speed data services. It is a cost-effective alternative to traditional lower-speed switched or full-time services and provides the downstream throughput that is necessary for effective professional Telecommuting based on the Internet and Intranets.

With the passive voice splitters lifeline POTS may be integrated with RADSL data on the same line.

RADSL-DMT

Ascend has announced support for DMT-based RADSL and while the basic functionality will be the same as the RADSL-CAP products, the precise specifications will differ slightly. The Ascend RADSL-DMT solution will support 640 Kbps upstream and 6.14 Mbps downstream at a 12,000 foot local loop, and 176 Kbps upstream and 1.54 Mbps downstream at an 18,000 foot local loop. RADSL-DMT will also support lifeline POTS. Availability: Q2 '98.

Module Summary

Module Type	RADSL-CAP
Module Model Number/Part Number	TNT-SL-ADSLC6
DSLNT Slots Occupied	One
Transfer Rates – Downstream/Upstream	7.168 Mbps/1.088 Mbps up to 10,000 feet (3.05 km)
Rates at X Distance:	2.560 Mbps/1.088 Kbps up to 12,000 feet (3.7 km)
	640 Kbps/544 Kbps up to 17,000 feet (5.18 km)
Connector Requirements	DB37 to 50-pin telco connectors
Module Weight	Approx. 3.9 lbs (1.77 kg)
Module Dimensions	8.8 in high x 10.6 in long (22.35 cm x 26.92 cm)
Hot-swap Capability	Yes
Operating Temperature	32° to 104° F (0° to 40° C)
Operating Humidity	10% to 90%, non-condensing
CPU Type/Speed	Intel i960 RISC Processor
Interfaces per Card	6
Max. Number of modules per Shelf	15
Max. Number of modules per System*	45
Line Encoding	CAP (Carrierless Amplitude Phase)
Protocols Supported	IP, IPX, PPP, Frame Relay
CPE Support	Ascend DSLPipe-C
Other	Lifeline POTS service with splitter

**A system can be made up of up to 3 shelves. A single DSLTNT chassis is referred to as a shelf.*

10Base-T Ethernet Module

The 10Base-T Ethernet module has four 10Base-T interfaces; each of which is a numbered interface with its own collision domain. The DSLTNT four-port Ethernet module provides multi-port Ethernet multiplexing capabilities. Multiplexing can be done between anyone of the 10Base-T interfaces to any WAN port, or any other LAN port on the DSLTNT.

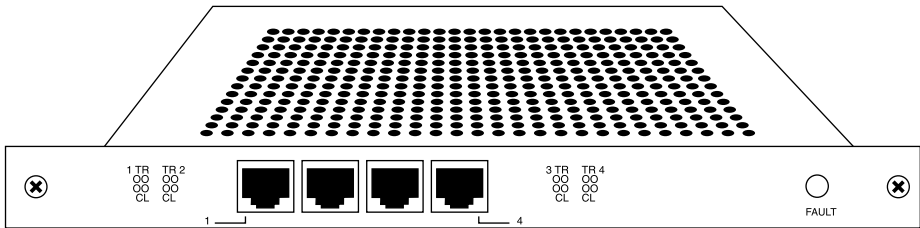


Figure 29 – 10Base-T Ethernet module

Up to four 10Base-T modules can be used in a three-shelf DSLTNT system for a total of up to 16 ports. This Ethernet module was designed to provide basic multi-segment LAN to WAN access.

Module Summary

Module Type	10Base-T Ethernet
Module Model Number/Part Number	TNT-SL-E10
DSLNT Slots Occupied	One
Transfer Rate	10 Mbps
Transmission Distance	100 Meters
Connector Requirements	RJ45
Module Weight	Approx. 3.9 lbs (1.77 kg)
Module Dimensions	8.8 in high x 10.6 in long (22.35 cm x 26.92 cm)
Hot-swap Capability	Yes
Operating Temperature	32° to 104° F (0° to 40° C)
Operating Humidity	10% to 90%, non-condensing
CPU Type/Speed	Intel i960 RISC Processor
Interfaces per module	4 X 10Base-T
Max. Number of modules per Shelf	4
Max. Number of modules per System*	4
Cable Requirements	Category 3 or Higher, Category 5 Recommended
Protocols Supported	RIP, RIPv2, OSPF, OSPF NSSA
Standards Compliance	802.3

* A system can be made up of up to 3 shelves. A single DSLTNT chassis is referred to as a shelf.

10/100Base-T Ethernet Module

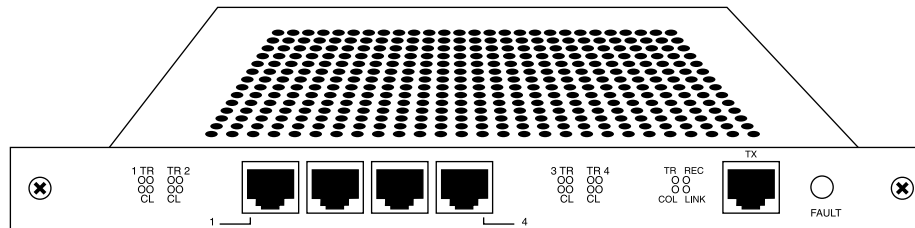


Figure 30 – 10/100Base-T Ethernet module

The 10/100 Ethernet module is identical to the 4-Port 10Base-T Ethernet module but has four 10Base-T interfaces and one 100Base-T interface. Up to four 10/100Base-T modules can be used in a three-shelf DSLTNT system for a total of up to 20 ports. This Ethernet module was designed to provide basic multi-segment LAN to WAN access.

Module Summary

Module Type	10/100Base-T Ethernet
Module Model Number/Part Number	TNT-SL-E100-TX
DSLTNT Slots Occupied	One
Transfer Rate	10/100 Mbps
Transmission Distance	100 Meters
Connector Requirements	RJ45
Module Weight	Approx. 3.9 lbs (1.77 kg)
Module Dimensions	8.8 in high x 10.6 in long (22.35 cm x 26.92 cm)
Hot-swap Capability	Yes
Operating Temperature	32° to 104° F (0° to 40° C)
Operating Humidity	10% to 90%, non-condensing
CPU Type	Intel i960 RISC Processor
Interfaces per module	4 x 10Base-T, 1 x 100Base-T
Max. Number of modules per Shelf	4
Max. Number of modules per System*	4
Cable Requirements	Category 5
Protocols Supported	RIP, RIPv2, OSPF, OSPF NSSA
Standards Compliance	802.3, 802.3u

*A system can be made up of up to 3 shelves. A single DSLTNT chassis is referred to as a shelf.

Serial WAN Module

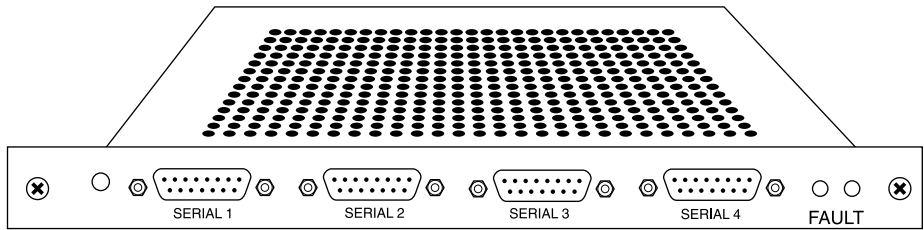


Figure 31 – Serial WAN module

The Serial WAN module has four high-speed V.35 ports, each of which supports data rates of up to 8 Mbps. This module is designed to provide direct connections to a Frame Relay or packet switch and is functionally equivalent to the WAN serial port on the MAX 4000 series product. Because there may be compression over the WAN serial interfaces, hardware-based STAC compression is included on this module. Up to six Serial modules can be used in a DSLTNT shelf for a total of up to 24 ports.

Module Summary

Module Type	Serial WAN module
Module Model Number/Part Number	TNT-SL-S8
DSLTNT Slots Occupied	One
Transfer Rate	Up to 8 Mbps
Module Weight	Approx. 3.9 lbs (1.77 kg)
Module Dimensions	8.8 in high x 10.6 in long (22.35 cm x 26.92 cm)
Hot-swap Capability	Yes
Operating Temperature	32° to 104° F (0° to 40° C)
Operating Humidity	10% to 90%, non-condensing
CPU Type/Speed	Intel i960 RISC Processor
Interfaces per module	4
Max. Number of modules per Shelf	6
Max. Number of modules per System*	18
Protocol Support	Frame Relay, PPP
Standards Compliance	RS-449/422 , V.35 , X.21
Other	Hardware STAC Data Compression (Hi/Fn) – supports STAC, Ascend and Microsoft compression.

*A system can be made up of up to 3 shelves. A single DSLTNT chassis is referred to as a shelf.

T1/PRI/E1 Module

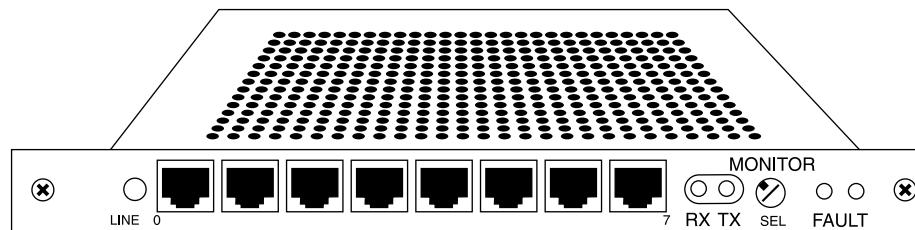


Figure 32 – T1/PRI module

The T1/PRI module has eight T1 interfaces with a built-in CSU for every port. Up to four T1 modules can be used in a single DSLTNT shelf for a total of up to 24 ports. The T1/PRI card does not do any data processing but forwards the raw DS0s/B-channels directly to the TDM bus for processing by the other expansion modules.

The T1 card supports tone generation and detection on all interfaces, thereby supporting DNIS digits on a DS1 as well as on PRI interfaces.

Note: Due to phone company definitions of “Yellow Alarm” and the fact that D4 framing was initially designed with voice circuits in mind, when operating in D4 Framing mode the T1 module is limited to 23 channels of HDLC data to prevent false yellow alarm.

When using 56 Kbps modems with D4 Framing, you must use the 56 Kbps data setting (not the 64 Kbps setting) due to the one’s density rule and robbed bit signaling must be turned off.

Module Summary

Module Type	T1/PRI module	Octal E1/PRI module
Module Model Number/Part Number	TNT-SL-CT1	TNT-SL-CE1
DSLNT Slots Occupied	One	One
Transfer Rate	1.544 Mbps, 24 DS0s	2.048 Mbps, 32 DS0s
Connector Requirements	RJ45	120 Ohm RJ45, 75 Ohm Coax
Module Weight	Approx. 3.9 lbs (1.77 kg)	Approx. 3.9 lbs. (1.77 kg)
Module Dimensions	8.8 in high x 10.6 in long (22.35 cm x 26.92 cm)	8.8 in high x 10.6 in long (22.35 cm x 26.92 cm)
Hot-swap Capability	Yes	Yes
Operating Temperature	32° to 104° F (0° to 40° C)	32° to 104° F (0° to 40° C)
Operating Humidity	10% to 90%, non-condensing	10% to 90%, non-condensing
CPU Type/Speed	Motorola 68360	Motorola 68360
Clocking	Provide or Sync to existing clock	Provide or Sync to existing clock
Interfaces per module	8 X RJ45	8 X RJ45, 8 X BNC
Max. Number of modules per Shelf	4 ²	4 ²
Max. Number of modules per System*	4 ²	4 ²
Max. Number of Analog/Digital Sessions	184	240
Switch Type Support	AT&T, NTI, NI-1	ITR6, Australian, NET5, R2, VN3, DPNSS, DASS2, CAS
Framing Support	AMI, B8ZS	B8ZS
Line Encoding Support/Frame Type	D4, ESF	G703/G704, 2DS, D4, ESF
Signaling Support	In-band, ISDN, NFAS	ISDN, DPNSS/DASS2, R2
Other	Integrated CSU on each port	No Integrated CSUs

*A system can be made up of up to 3 shelves. A single DSLTNT chassis is referred to as a shelf.

²Maximum of 28 T1s/E1s per DSLTNT system (672/720 DS0s respectively).

FrameLine (Frame Relay) Module

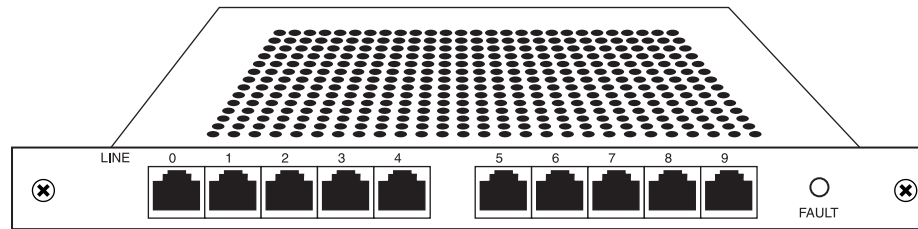


Figure 33 – FrameLine (Frame Relay) module

The Frameline module has 10 unchannelized T1 interfaces and integrated HDLC controllers so that it can provide the complete Frame Relay solution in a single module. DSLTNT includes Frame Relay software option.

You manage the T1 ports on the FrameLine card similar to the T1 ports on the existing eight-port T1 card. The FrameLine card can only be used for nailed Frame Relay or PPP links.

PPP support

Bandwidth per session is 1-24 DS0 channels and the channels need not be contiguous.

Frame Relay support

Bandwidth per link is 1-24 DS0 channels. Channels need not be contiguous. Up to 120 DLCIs are supported per card.

Note: Due to phone company definitions of “Yellow Alarm” and the fact that D4 framing was initially designed with voice circuits in mind, when operating in D4 Framing mode the T1 module is limited to 23 channels of HDLC data to prevent false yellow alarm.

When using 56 Kbps modems with D4 Framing, you must use the 56 Kbps data setting (not the 64 Kbps setting) due to the one’s density rule and robbed bit signaling must be turned off.

Module Summary

Card Type	Frameline
Card Model Number	TNT-SL-FL10
DSLNT Slots Occupied	One
Transfer Rate	1.544 Mbps +/- 32ppm
Transmission Distance	Standard
Connector Requirements	RJ45
Module Weight	Approx. 3.9 lbs (1.77 kg)
Module Dimensions	8.8 in high x 10.6 in long (22.35 cm x 26.92 cm)
Hot-swap Capability	Yes
Operating Temperature	32° to 104° F (0° to 40° C)
Operating Humidity	10% to 90%, non-condensing
CPU Type/Speed	Intel i960 RISC Processor
Interfaces per Card	10 RJ45 (100 ohm line)
Max. Number of modules per Shelf	2 ²
Max. Number of modules per System*	2 ²
Protocol Support	Frame Relay, PPP, HDLC
DLCIs Supported	120
PVCs per module/System	10/956
Electrical	DSX-1 per ANSI T1.102 (DSX) DS1 per ANSI T1.403, Pub 62411 (CSU)
Line Build Out	0dB, -7.5db, -15db, -22.5db (CSU) 0-133 ft, 133-266 ft, 266-399 ft, 399-533 ft, 533-655 ft (DSX)
Line Code	AMI, B8ZS
Frame Format	Per ANSI T1.107a (M23 or C-Bit Parity)
LED	Single LED, which functions identically to the LED for the eight-port T1 card
Alarm Signaling	Red Alarm, yellow signal
Other	Integral CSUs, Integral HDLC Processors, also called Serial Communications Adapter (SCA)

*A system can be made up of up to 3 shelves. A single DSLTNT chassis is referred to as a shelf.

²Maximum of 28 T1s/E1s per DSLTNT system (672/720 DS0s respectively).

Appendix Two: MultiDSL Performance Results

RADSL Line Performance Test

Set up:

TNT → Cable load → CPE — PC#1

Test Results:

Note: 1. ADSL TNT line card code version: 2.0.0eo and RADSL CPE code version: 6.0.0eo.
2. Acceptable Line-Q db range is between 18.0db to 70.0 db.

2. Data Rate = 2560000

Wire Gauge: 24 awg

Length	0	2000	4000	6000	8000	10000	12000	14000	16000	18000
Down Rate	2560k	2560k	2560k	2560k	2560k	2560k	2560k	2240k	1280k	640k
Up Rate	1088k	1088k	1088k	1088k	1088k	1088k	1088k	1088k	952k	816k
Line Q	45	45	45	45	45	45	43	35	26	20
Data Ping	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

Wire Gauge: 26 awg

Length	0	2000	4000	6000	8000	10000	12000	14000	15000
Down Rate	2560k	2560k	2560k	2560k	2560k	2560k	1920k	640k	640k
Up Rate	1088k	1088k	1088k	1088k	1088k	1088k	952k	680k	544k
Line Q	45	45	45	45	45	42	32	21	16
Data Ping	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

LOOP

Loop	MID CSA 5	MID CSA 6	EXT CSA 10	CSA Loop 8	CSA Loop 6	CSA Loop 5	CSA Loop 1	ANSI Loop 8	ANSI Loop 9	ANSI Loop 11	ANSI Loop 15
Down Rate	2560k	2560k	1920k	2560k	2560k	2560k	2560k	640k	1280k	960k	1920k
Up Rate	1088k	1088k	952k	1088k	1088k	1088k	1088k	544k	544k	680k	952k
Line Q	45	45	42	45	45	45	45	16	25	24	32
Data Ping	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

RADSL Line Performance Test

Set up:

TNT → Cable load → CPE — PC#1

Test Results:

Note: 1. ADSL TNT line card code version: 2.0.0eo and ADSL CPE code version: 6.0.0eo.
2. Acceptable Line-Q db range is between 18.0db to 70.0 db.

1. Data Rate = 7168000

Wire Gauge: 24 awg

Length	0	2000	4000	6000	8000	10000	12000	14000	15000
Down Rate	7168k	7168k	7168k	7168k	7168k	4480k	2688k	2688k	
Up Rate	952k	1088k	952k	952k	680k	680k	408k	408k	
Line Q	36	36	41	36	41	35	26	16	
Data Ping	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail

Wire Gauge: 26 awg

Length	0	2000	4000	6000	8000	10000	11000	12000
Down Rate	7168k	7168k	7168k	7168k	6272k	2688k	2688k	
Up Rate	952k	952k	952k	680k	408k	408k	408k	
Line Q	36	36	36	36	36	25	16	11
Data Ping	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail

LOOP

Loop	MID CSA 5	MID CSA 6	EXT CSA 10	CSA Loop 8	CSA Loop 6	CSA Loop 5	CSA Loop 1
Up Rate	680k	680k		408k		408k	408k
Down Rate	6272k	7168k		2688k		4480k	4480k
Line Q	40	36	11	11	36	11	36
Data Ping	Pass	Pass	Fail	Pass	Fail	Pass	Pass

IDSL Line performance Test

Set up:

TNT → Cable load → CPE — PC#1

Test Results:

IDSL TNT line card code version: 2.0.0eo and IDSL P75U CPE code version: 5.1Ap1

Wire Gauge:24 awg

length	0	2000	4000	6000	8000	10000	12000	14000	16000	17000	18000
Line Q-db	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Data rate	128k	128k	128k	128k	128k	128k	128k	128k	128k	128k	128k
Ping data	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

Wire Gauge:26 awg

length	0	2000	4000	6000	8000	10000	12000	14000	15000
Line Q-db	NA	NA	NA	NA	NA	NA	NA	NA	NA
Data rate	128K	128K	128K	128K	128K	128K	128K	128K	128K
Ping data	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

SDSL Line Performance with TAPs

Test Setup

TNT(SDSL Line card) → (A) Line Simulator (B) → SDSL CPE ↔ PC#1

AWG 26+Taps

Line Simulator TAP setup

TAP A = 1500 ft

Cable Length = 8000 ft

TAP B = 1000 ft

Result: Measured Line Q = 7 db and data traffic pass successfully.

AWG 24+Taps

Line Simulator TAP setup

TAP A = 1500 ft

Cable Length = 12000 ft

TAP B = 1500 ft

Result: Measured Line Q = 8 db and data traffic pass successfully.

Set up:

TNT → Cable load → CPE — PC#1

Test Results:

SDSL TNT line card code version: 2.0.0eo and SDSL CPE code version: 6.0.0eo

Wire Gauge: 24 awg

length	0	2000	4000	6000	8000	10000	12000	14000	16000	17000	18000
Line Q-db	15	15	15	15	15	15	15	11	7	-16	-16
Data rate	784K	784K	784K	784K	784K	784K	784K	784K	784K	0	0
Ping data	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail

Wire Gauge: 26 awg

length	0	2000	4000	6000	8000	10000	12000	14000	15000
Line Q-db	15	15	15	15	15	10	-11	-16	-16
Data rate	784K	784K	784K	784K	784K	784K	0	0	0
Ping data	Pass	Pass	Pass	Pass	Pass	Pass	Fail	Fail	Fail

Note:

Acceptable Line-Q db range is between -5.0db to 10.0 db.

Common Language Equipment Identifier (CLEI)

Model Number	CLEI Code	Description
DSLNT-DC	NCM4BAoARA	DSLNT with DC power supply
TNT-SL-ADSLC6	NCD2GFoAAA	6-port ADSL-CAP card for DSLNT
TNT-SL-IDSL32	NCD2UToAAA	32-port IDSL card for DSLNT
TNT-SL-SDSL16	NCD2HGAAA	16-port SDSL card for DSLNT
TNT-SL-FL10	NCD2SRoAAA	10-port T1/Frame Line card for TNT
TNT-SL-S8	NCD2FCoAAA	4-port SWAN card for TNT
DSL-ACAP	NCD2KJoAAA	RADSL-CAP based DSLPipe (CPE)
DSL-S	NCD2LKoAAA	SDSL based DSLPipe (CPE)
ADSL-COE-C	NCD2JHoAAA	RADSL-CAP based DSLPipe (COE)

For more information, please refer to Bell Communication Research GR-485-CORE, ISSUE 2, October, 1995.

DSLNT Power Consumption Measurements

The following table outlines the typical power consumption numbers of the TNT and its various optional line/slot cards (SC). It should be noted that these numbers are steady state (i.e. do not compensate for power-up in-rush, etc.) and were measured from one typical unit (i.e. were not averaged over any sample size).

Item	Consumption (Amps)	Consumption (Watts)	Dissipation (BTU/h)
Un-populated Chassis (i.e. Fan System only) Single DC Supply	2.0 A @ 48V	96 W	328 BTU/h
Un-populated Chassis (i.e. Fan System only) Redundant DC Supply	2.4 A @ 48V	115 W	393 BTU/h
Shelf Controller (12 V is negligible)	3.4 A @ 5 V 17 W	58 BTU/h	
6-port ADSL (RADSL-CAP)	6 A @ 5 V	30 W	102.3 BTU/h
16-port SDSL	4 A @ 5 V	20 W	68.2 BTU/h
32-port IDSL	3.2 A @ 5 V	16 W	54.56 BTU/h
Ethernet 100 SC	3.4 A @ 5 V	17 W	58 BTU/h
Channelized T1 SC	1.5 A @ 5 V	7.5 W	26 BTU/h
Hybrid Access SC	3.5 A @ 5 V	17.5 W	60 BTU/h
Channelized T3 SC	3.0 A @ 5 V	15 W	51 BTU/h
Serial WAN SC	3.98 A	20 W	68 BTU/h
FrameLine10 SC	2.75 A @ 5 V	13.75 W	47 BTU/h

† These are estimated numbers based on design calculations. Actual measured numbers will be provided just as soon as hardware is available.

Other Information:

- Each DC supply unit (based on dual VICOR 400 Watt modules) has a rated efficiency of at least 82% @ 50% load.
- The backplane is designed for a maximum power budget per slot card = 7A (i.e. not to exceed).

MultiDSL Local Loop Requirements

IDS

- Satisfactory performance level at $<10^{-7}$ BER is assumed
- Non-loaded loop, no load coils
- Reach figures assume that no bridge-taps are present
- Reach figures assume that near-end crosstalk is negligible
- Reach distance
 - 128 Kbps, symmetric data rate, single pair of wires,
 - 18,000 ft. (5.5 km) 24 AWG twisted pair, approx. 925 ohms
 - 15,000 ft. (4.5 km) 26 AWG twisted pair, approx. 1230 ohms
- Maximum line attenuation is 42 dB loss at 40 kHz into 135 ohms
- Nominal impedance reference is 135 ohms
- Echo-cancellation accommodates expected impedance variations
- Requires minimum 6dB margin relative to reference crosstalk model on most loops as defined in ANSI T1.601-1992

SDSL

- Satisfactory performance level at $<10^{-7}$ BER is assumed
- Non-loaded loop, no load coils
- Reach figures assume that no bridge-taps are present
- Reach figures assume that near-end crosstalk is negligible
- Reach distance
 - 768 Kbps, symmetric data rate, single pair of wires,
 - 16,000 ft. (4.8 km) 24 AWG twisted pair, approx. 820 ohms
 - 10,000 ft. (3.0 km) 26 AWG twisted pair, approx. 820 ohms
- Maximum line attenuation is 31 dB loss at 150 kHz into 135 ohms
- Nominal impedance reference is 135 ohms
- Echo-cancellation accommodates expected impedance variations
- Signal-to-Noise Ratio (SNR) requirements
 - Minimum 20 dB SNR relative to shaped noise as defined in ANSI T1E1.4/94-006
 - Minimum 17.5 dB SNR relative to shaped noise as defined in ETSI ETR 152 December 1996

RADSL-CAP

- Satisfactory performance level at $<10^{-7}$ BER is assumed
- Non-loaded loop, no load coils
- Reach figures assume that no bridge-taps are present
- Reach figures assume that near-end crosstalk is negligible
- Rate-adaptation allows a wide range of line quality
- Reach distance and attenuation varies with adapted rate
- Reach distance when maximum downstream rate set to: 2.560000 Mbps
 - 12,000 ft 24 AWG at 2560 Kbps downstream rate
 - 10,000 ft 26 AWG at 2560 Kbps downstream rate
 - 18,000 ft 24 AWG at 640 Kbps downstream rate
 - 15,000 ft 26 AWG at 640 Kbps downstream rate
- Depending upon the line condition, the other data rates that the RADSL can synchronize when maximum downstream speed is set to: 2.56 Mbps:
 - Downstream rates: 2.56 Mbps, 2.24 Mbps, 1.92 Mbps, 1.6 Mbps, 1.28 Mbps, 960 Kbps, 640 Kbps
 - Upstream rates: 1.088 Mbps, 952 Kbps, 816 Kbps, 680 Kbps, 544 Kbps, 408 Kbps, 272 Kbps
- Reach distance when maximum downstream rate set to: 7.168000 Mbps
 - 8,000 ft 24 AWG at 7.168 Mbps downstream rate
 - 6,000 ft 26 AWG at 7.168 Mbps downstream rate
 - 14,000 ft 24 AWG at 2688 Kbps downstream rate
 - 11,000 ft 26 AWG at 2688 Kbps downstream rate
 - Depending upon the line condition, the other data rates that the RADSL can synchronize when maximum downstream speed is set to 7.168000 Mbps:
 - Downstream rates: 7.168 Mbps, 2.56 Mbps
 - Upstream rates: 1.088 Mbps, 952 Kbps, 816 Kbps, 680 Kbps, 544 Kbps, 408 Kbps, 272 Kbps
- Nominal impedance reference is 100 ohms
- Impedance variations are accommodated since the system is very echo tolerant due to the use of Frequency Division Multiplexing to separate the upstream and downstream channels
- Signal-to-Noise Ratio (SNR) requirements relative to colored noise
 - When maximum downstream rate set to: 2.560000 Mbps
 - minimum 10 dB SNR at 640 Kbps downstream rate
 - minimum 29 dB SNR at 2560 Kbps downstream rate
- Signal-to-Noise Ratio (SNR) requirements relative to colored noise
 - When maximum downstream rate set to: 7.168000 Mbps
 - minimum 14.6 dB SNR at 2688 Kbps downstream rate
 - minimum 28.7 dB SNR at 7162 Kbps downstream rate
- Software configurable (downstream) speed rates are: 7.168 Mbps, 6.2 Mbps, 5.1 Mbps, 4.4 Mbps, 3.2 Mbps, 2.56 Mbps, 2.2 Mbps, 1.9 Mbps, 1.6 Mbps, 1.2 Mbps, 960 Kbps, 640 Kbps
 - The maximum upstream data rate is always set to 1.088 Mbps.

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