Product information begins on page 2.

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RESOURCE GUIDE

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RESOURCE GUIDE

MultiDSL For Service Providers

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MultiDSL for Service Providers

An introduction and overview of the Digital Subscriber Line (DSL) technologies and business opportunities for Competitive Access Providers, Independent Telephone Companies, Internet Service Providers, Building Managers, and Utility Companies.

Table of Contents

1. Introduction

Digital Subscriber Line (DSL) technology transforms traditional inexpensive copper phone lines into high-speed, high-value data service lines. DSL is particularly valuable today because it addresses the immediate needs of businesses and consumers for high-speed Internet access. DSL also provides LAN to LAN internetworking solutions that are cost effective and quickly provisioned.

Because of the rapid Internet growth, increased popularity of telecommuting and increased demand for bandwidth, the market for DSL is projected to grow to over 3.5 million lines by the 1999[1]. At the same time the Internet services market is expected to grow from $1.3 billion to over $29 billion[2]. These market dynamics will fundamentally transform the telecommunications and data communications services.

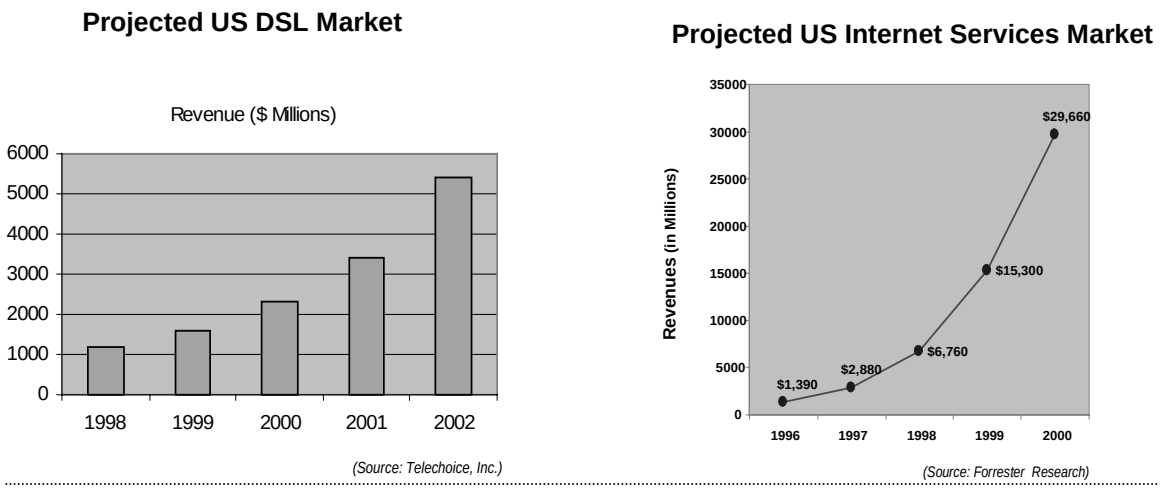

Figure 1 – The DSL and Internet Services Markets are Growing Rapidly

This resource guide provides an overview of DSL technologies, discusses design and deployment considerations, and outlines how companies can benefit by providing DSL. Specifically, this resource guide shows how organizations are realizing incremental gross profits of up to $100,000 per month per Ascend DSL concentrator[3] by implementing DSL technology today.

This resource guide is divided into nine sections to cover all the information requirements for initiating DSL services:

Section 1 describes the business opportunity that DSL presents, and where the technology is best deployed.

Section 2 provides the introduction and short tutorial on the key DSL technologies.

Section 3 outlines the unique advantages of DSL and how profits can be made from deploying DSL.

Section 4 provides an overview of the typical applications for DSL technologies.

Section 5 offers an overview of the types of DSL equipment that is available on the market today.

Section 6 covers the DSL equipment from Ascend that allows you to provide the full range of DSL services.

Section 7 provides several examples of the cash flow you might obtain using the Ascend DSL solutions.

Section 8 reviews the available line monitoring and diagnostic tools that are provided as part of the Ascend MAX products, and introduces complementary third party products.

Section 9 provides a summary of the many benefits you gain by partnering with Ascend; the leader in the access concentrator market.

[1] Telechoice, Inc. 1996
[2] Forester Research, 1996
[3] Ascend DSL ROI Example, Section 10 of this document

2. DSL – The Technology

DSL, or Digital Subscriber Line, refers to a group of digital data services which support speeds from 128 Kbps to 7 Mbps over standard copper phone lines. The first true DSL was ISDN and while that service has become popular, the limited bandwidth options make it less appealing than the newer high-speed alternatives that have been developed. Bell Communications Research Inc. (Bellcore) developed the first ADSL specifications in 1987 for delivery of Video On Demand (VoD) and interactive TV services and to provide a competitive response to the CATV industry's plans to enter traditional Telco markets. Since that time a number of variations on that core DSL technology have been created.

DSL Summary

The leading commercial versions of DSL technology available today are as follows:

Technology	Description	Symmetry	Downstream Speed	Upstream Speed	Wiring
IDSL	ISDN DSL	Symmetric	Up to 128 Kbps	Up to 128Kbps	single pair
SDSL	Single-Pair DSL	Symmetric	Up to 1.544 Mbps	1.544 Mbps	single pair
HDSL	High-speed DSL	Symmetric	Up to 1.544 Mbps	Up to 1.544 Mbps	two pairs
ADSL	Asymmetric DSL	Asymmetric	Up to 7 Mbps	Up to 1.0 Mbps	single pair

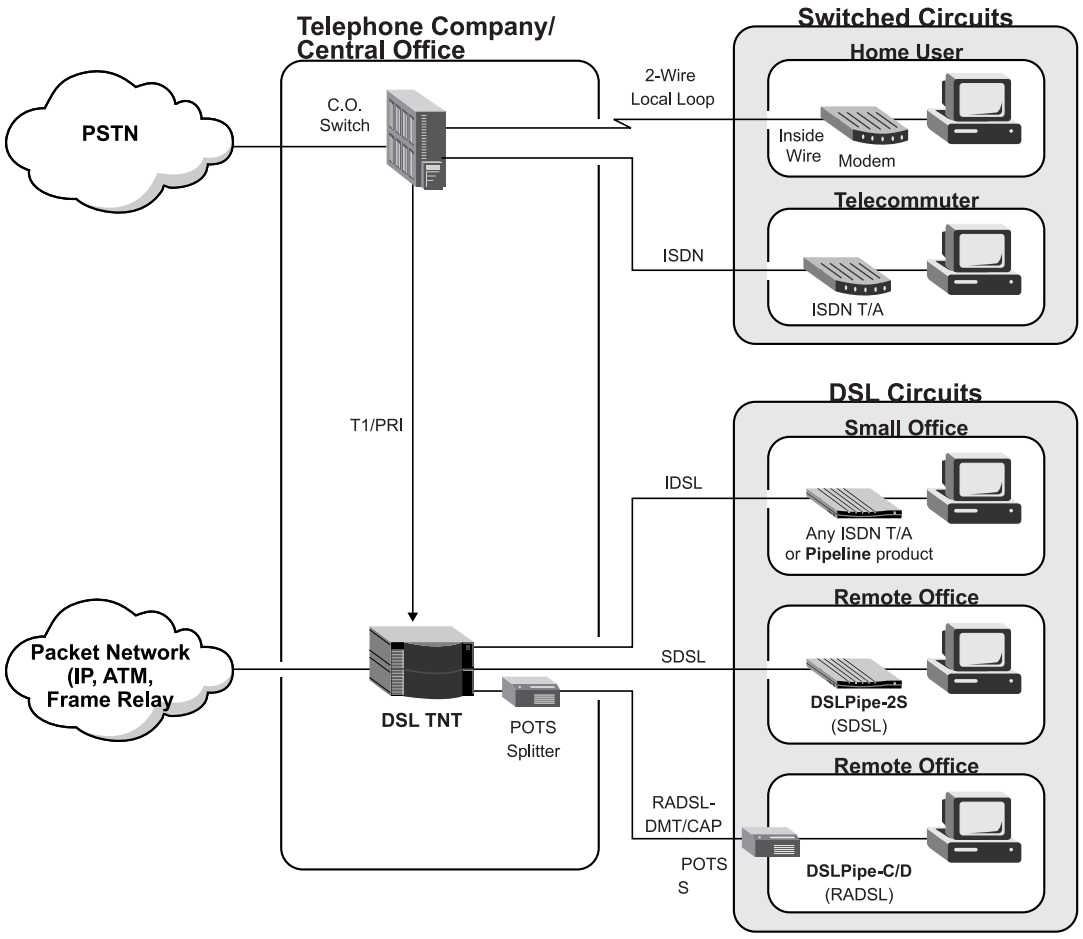

Figure 2 – Ascend supports both traditional access technologies such as analog and ISDN, and the newest DSL technologies.

While IDSL and ADSL are now being installed in increasing numbers around the country, the HDSL variation has been used for several years as a replacement for traditional 1.544 Mbps T1 services. In fact in 1996 it is estimated that approximately 60% of all T1 lines were provisioned via HDSL[4], representing over 179,000 lines. T1 lines have been installed for many decades, but they've traditionally required technicians to "condition" the line with repeaters, and to follow specific design constraints in "bundling" of these lines to avoid cross-talk; an expensive and time-intensive operation. In contrast DSL lines need no special conditioning and therefore are much cheaper to install and maintain.

HDSL is the oldest of the DSL technologies and is now being superceded by single pair DSL technologies that allow companies to more efficiently use their twisted pair wiring infrastructure. With technologies like SDSL, two pair are required only when a full 1.54 Mbps is needed whereas HDSL always requires two pairs. Because most homes are installed with a single pair of wires, SDSL is much more easily used to offer a 768 Kbps service using the existing pair of wire as opposed to having to install an additional pair as required by HDSL.

DSL was originally designed to allow regular phone services even in the event of power outages – in what is termed "lifeline POTs" or "Plain Old Telephone Service." This feature is still available in the ADSL and RADSL variations of DSL. In fact with ADSL and RADSL users get the benefits of using only a single-pair of wiring, but get both high-speed digital data services and their regular lifeline telephone service over that wiring. It is for this reason that these high-speed DSL solutions are particularly attractive in the home environments.

Key advantages of DSL over traditional copper-based data services are:

1. High data rates over standard telephone wiring, over long distances
2. Independence from the traditional Public Switched Telephone Network (PSTN)/Offloads PSTN
3. Full-time connectivity
4. Inexpensive to implement, Inexpensive to add to
5. Revenue opportunity for Telcos and non-telcos

1. High Data Rates over Standard Telephone Wiring

Local phone companies (also referred to as Local Exchange Carriers, or LECs) have invested billions of dollars over the past 100 years developing a copper wire infrastructure that provides connectivity to every home and business for phone services. These standard analog services require 300Hz-3,400 Hz of bandwidth on the "local loop" of copper wiring between traditional central office switches and customer premises. These same wires are, however, capable of carrying information at much higher rates when modern digital signal processing technologies are used. The explosive growth in Internet access, as well as remote LAN access and telecommuting has resulted in a high demand for faster data services. DSL technologies utilize a bandwidth of up to 1.2 MHz (over 300 times the bandwidth of an analog phone call), and allows data speeds of over 7 Mbps.

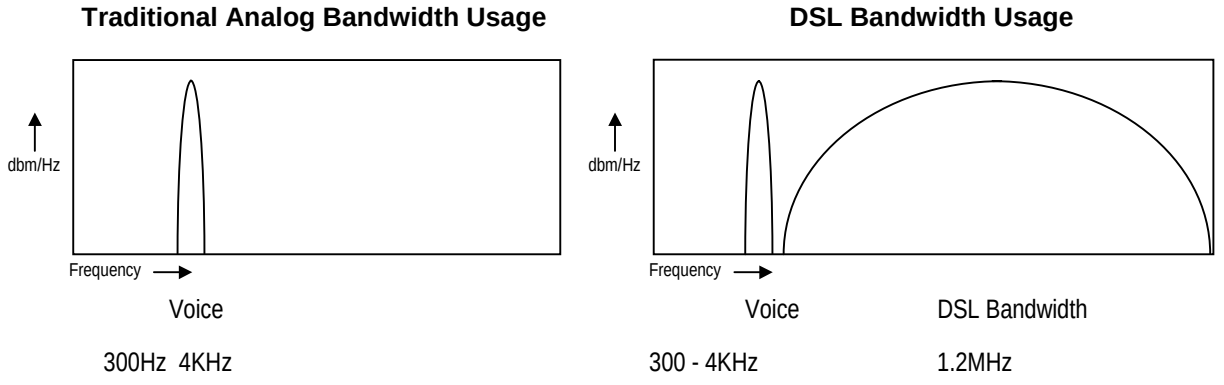

Figure 3 – DSL uses more of the available bandwidth and can therefore transmit more data.

[4] Broadband Networking News, Sept. 30 1997

2. Independence From the Traditional Public Switched Telephone Network (PSTN)

A significant advantage of DSL solutions for telephone companies is the separation of packet-based data traffic from voice traffic. The PSTN was designed to provide an extremely high level of availability for voice calls. The average voice call lasts 3 minutes, data traffic has very different usage characteristics than typical voice traffic. The average Internet access call via analog modem is over 20 minutes long – the equivalent of about five voice calls – and this is overloading the PSTN. Unlimited usage (flat-rate) internet access services now offered by most ISPs further exacerbate this problem. To avoid busy signals it is not uncommon for users to dial and stay connected for hours, or even days. Carriers are therefore faced with two choices: they can either upgrade the PSTN to handle the increasing demand, or they must move the majority of data traffic to a separate network designed specifically for data communications. Central office telephone switches are extremely expensive as data switches, and offer poor performance. Offloading data traffic is the only viable long-term solution. DSL effectively accomplishes this while offering better performance at a much lower cost.

3. Full-time Connectivity

DSL services offer full-time connectivity for end users – a feature that is becoming increasingly important in Internet access situations. Businesses are hosting web-servers in their offices for access by potential customers via the Internet. Switched services (i.e. dialed calls) are not appropriate for web-hosting applications because they are not designed to provide the full-time connectivity or the bandwidth necessary for business internet access. In contrast, DSL is an ideal technology for this application because DSL is a packet-switched service and there is never an end-to-end circuit that must be kept open to the exclusion of other callers as in a switched voice network. DSL-based services are high-speed, full-time, connections and the companies offering these services can bill based on traffic levels, or on a flat monthly rate.

4. Inexpensive Implementation

Even large telephone companies are reluctant to make significant investments to upgrade existing PSTN equipment and facilities. New services – even those addressing the well-known demand for Internet access – are ideally available in smaller increments and at low cost so that companies can start with a minimal investment and then quickly scale up to meet demand changes. DSL offers this inexpensive and incremental approach to data services over standard copper wiring.

Packet switching – possible with data communications but not with traditional voice circuits – makes optimal use of end-to-end bandwidth because one user's idle time is filled with other users' traffic. A packet infrastructure is more efficient and more economical for data traffic (up to 100 times more efficient) because of the unused time on a dedicated circuit.

Packet-switched data networks also allow companies to leverage the low-cost digital processing technologies developed in the computer industry, as opposed to the much more expensive circuit-based networks of analog telephone technology. The digital nature of these data networks also allows for new services that utilize software developed by third parties such as Fax over IP services and Voice over IP.

Packet-based networks also allow for linear growth in small, incremental phases by adding line cards and additional concentrators as needed. The "pay as you go" approach offers welcomed relief from PSTN's dependence on significant, expensive upgrades to increase capacity.

It has been estimated that the Internet is doubling in traffic about every five to 10 months. Packet-switched technologies, which double in performance/cost every 10 to 20 months represent the only technology capable of keeping up. Circuit-switched technologies, which take approximately 80 months to double their performance/cost, would force ISPs or Carriers to deploy prohibitively expensive networks and still be unable to keep up with demand.

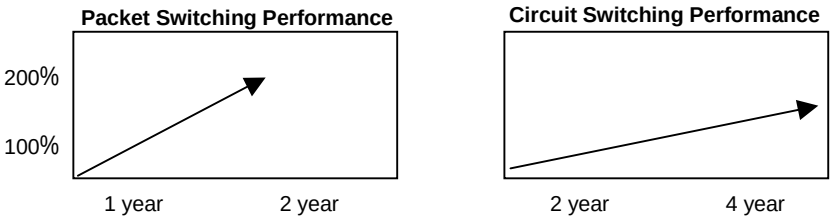

Figure 4 – Comparison: Packet Switching vs. Circuit Switching

5. Revenue Opportunities for Telcos and Non-Telcos

Four important factors combine to create a unique opportunity for existing and potential service providers:

- Clamoring for bandwidth
- Low cost of DSL technologies
- Telecom industry deregulation
- Availability of "free copper" in existing buildings and campus installations

The DSL revenue opportunity is therefore open to a large number of companies – traditional data service providers and non-traditional service providers. The immense investment in the copper infrastructure for the public telephone network has already been amortized over many voice calls and now DSL allows greatly increased performance at relatively minor cost.

IDSL – ISDN Digital Subscriber Line

IDSL (ISDN Digital Subscriber Line) leverages existing ISDN standards and compatibility. IDSL uses the ubiquitous 2B1Q line coding standard and operates at 128 Kbps for up to 18,000 feet.

Because IDSL uses the same industry-standard line coding technique as ISDN, customers can use existing off-the-shelf ISDN Terminal Adapters, routers and bridges for connecting to IDSL lines. Any of the commonly used transport protocols such as PPP, MP, MP+ or Frame Relay may be used over the IDSL line thereby allowing rapid and transparent integration into Internet, remote LAN access and telecommuting applications.

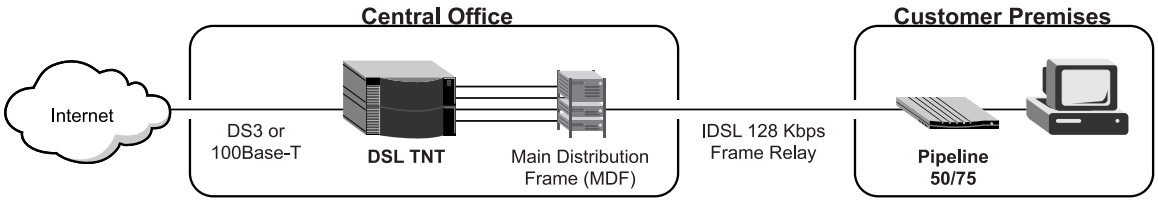

Figure 5 – IDSL Data Application

IDSL is the easiest to deploy of all the xDSL technologies since a majority of the local loops are "ISDN-ready" making them "IDSL-ready" as well. IDSL supports line lengths of up to 18,000 ft. and traditional data interference sources such as DLCs and repeaters do not interrupt the IDSL signal. Installation in most applications can be done with a minimum of hassle.

The first generation of IDSL technology brought data-only IDSL service at 128 Kbps to the market. This has helped pave an evolutionary path to the high-speed xDSL services. Ascend has further enhanced IDSL technology with the ability to integrate voice and data over the same IDSL circuit.

IDSL is ideal in small business or telecommuter applications where moderate data rates are required, and optional voice services may also be needed. IDSL's dedicated symmetric 128 Kbps of bandwidth is ideal for smaller businesses

with their own web servers, and for regular employee Internet access and email. As with the other DSL technologies, IDSL is applicable in either central office, highrise or campus environments.

IDSL is particularly valuable in regional telephone company applications where Internet access is becoming common but additional phone lines for data access may be difficult and expensive to install. IDSL allows the addition of high-speed data services without the costly upgrade of a central office switch to ISDN. Historically, to make a central office ISDN-ready, telcos needed a software upgrade to their digital switch; that upgrade may have cost anywhere from $200,000 to $500,000, depending on the type of the switch. IDSL allows regional telephone companies or network service providers to offer dedicated data service in addition to voice services, all on the same single pair of copper wire and with only a minimal incremental investment in equipment.

IDSL lines terminate at the Ascend DSLTNT™, MAX TNT™, and MAX™ 6000 or 4000 series at the Central Office (CO). The data can then be transmitted over an ATM Frame Relay high-speed or ethernet backbone network. IDSL provides dedicated access to a packet switched network. Customers subscribing to IDSL services can utilize any of the pre-defined services such as Internet access or destinations such as corporate headquarters at high-speeds with low cost.

IDSL Voice Support

If voice or fax support is required over the IDSL line (single pair of wires), an Ascend Pipeline® 75 or 85 with analog phone ports can be used as the CPE, allowing direct connection of an analog phone and/or a FAX machine.

By configuring the Pipeline units for IDSL, the Pipeline will permit integration of voice and data over a single pair of wires using IDSL service. When the phone goes off-hook, the user receives a dial tone from the Pipeline and enters the trunk group number followed by the phone number (similar to an ISDN Centrex service). The Pipeline then forwards the number over the IDSL line to the Ascend MAX unit at the central office. The MAX receives the number, recognizes the first digit as the trunk group number, strips off the first digit and routes the call to the appropriate T1 or T1/PRI line to the Central Office voice switch or to a voice PBX. Ascend uses the Multilink Protocol Plus (MP+) to multiplex the two IDSL B-channels together and provide voice services when needed.

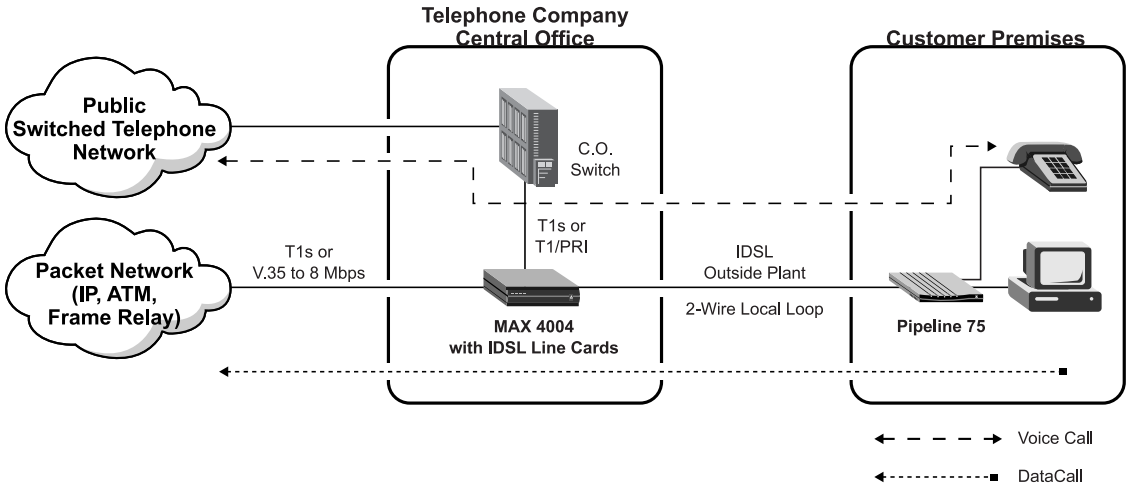

Figure 6 – IDSL for Central Office-based services for Voice and Data

SDSL – Single-Pair Digital Subscriber Line

Single-pair Digital Subscriber Line provides the same symmetric upstream and downstream bandwidth. SDSL uses the same technology as HDSL but on only a single pair of wires and up to 1.544 Mbps speeds. Internet service providers have found that the business data services market “sweet spot” is in the 256 Kbps to 1 Mbps range, and so for these applications SDSL is ideal.

For additional bandwidth two SDSL circuits can be combined using Multilink PPP or MP+ to act as a single 1.54 Mbps circuit using the Ascend DSLPipe-2S remote site router. Like IDSL and HDSL, SDSL relies upon 2B1Q line encoding and primarily used to provide high-speed Internet access, telecommuting applications or remote networking. SDSL is desirable for any application needing symmetric access (such as servers and remote LAN users), and therefore complements ADSL. Because it offers fast symmetrical performance economically on a single pair of wiring over a distance of up to 12,000ft, SDSL is an ideal solution where symmetric data services are needed. Additionally, Ascend’s DSLPipe-HS can provide up to 1.544 Mbps speeds over a singe pair of wires.

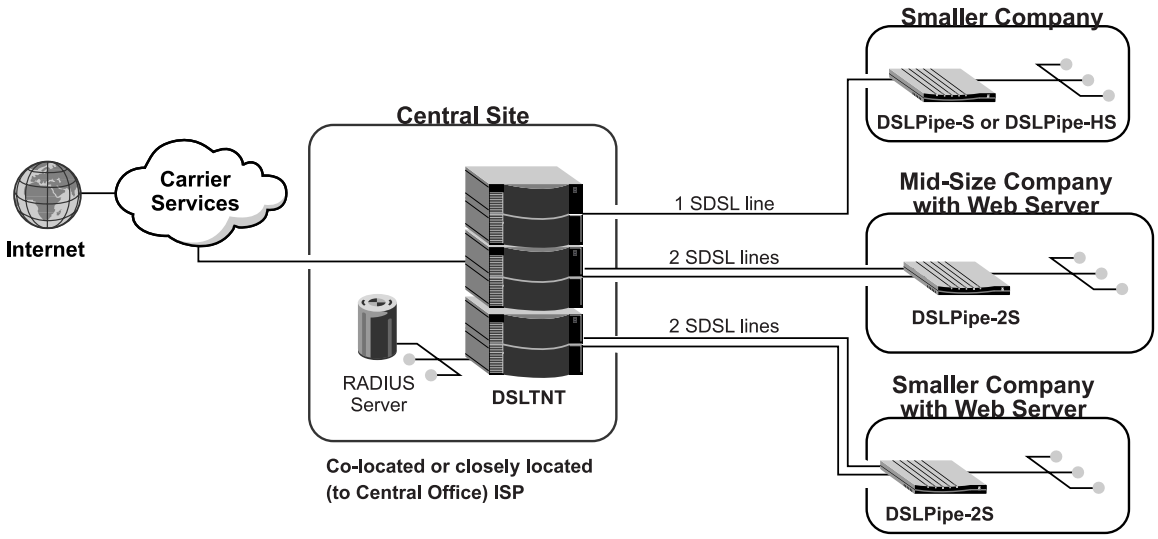

Figure 7 – Single line SDSL and dual line SDSL provide the symmetrical bandwidth that businesses need

ADSL – Asymmetric Digital Subscriber Line

ADSL started out as the phone company's way to compete with cable TV by delivering both TV and phone service on a standard copper phone line. Now however, it's ideal for personal high-speed Internet access with simultaneous voice services.

As its name implies, ADSL transmits an asymmetric data stream, with up to 7 Mbps downstream bandwidth (to the subscriber) and only up to 1 Mbps upstream bandwidth. The reason for this asymmetry has less to do with transmission technology than with the telephone cabling. Twisted pair telephone wires are bundled together in large cables. Fifty pair to a cable is a typical configuration towards the subscriber, but cables coming out of a central office may have hundreds or even thousands of pairs bundled together. An individual line from a Central Office to a subscriber is spliced together from many cable sections as they fan out from the central office. Twisted pair wiring was designed to minimize the interference of signals from one cable to another, but the process is not perfect. Signals do interfere with one another as frequencies and the length of line increase. In fact if you try to send symmetric signals in many pairs within a cable, you significantly limit the data rate and length of line you can attain.

Asymmetric solutions are targeted primarily at individual Internet subscribers who receive more information than they send; businesses will usually host web servers and need high-speed Internet bandwidth in both directions.

Two line coding schemes are possible with ADSL: Discrete Multi-Tone (DMT) and Carrierless Amplitude and Phase (CAP) modulation. Although the CAP version has been more widely deployed in trials, DMT is the version approved by ANSI's Working Group T1E1.4 as the industry standard. Currently both standards are under evaluation again and so it is unclear as to which will ultimately become the true industry standard, or if they will co-exist.

ADSL has two significant advantages:

- It is the fastest DSL technology that supports the maximum distance in the local loop.
- It supports lifeline "POTS"; or Plain Old Telephone Service.

With ADSL, data and lifeline POTS are provided as independent channels on a single line. SDSL technologies require a separate voice line – two lines total – to provide both services. This is not a problem in most newer buildings which are usually wired for at least of two lines, but ADSL does offer a significant edge in older houses and apartments served by a single line. These two advantages make ADSL the favored long-term solution among carriers and service providers addressing the consumer market.

With ADSL speeds, both upstream and downstream vary with distance:

- 7.0 Mbps downstream, 1.0 Mbps Upstream for up to 10,000 ft.
- 2.56 Mbps downstream, 1.0 Mbps upstream for up to 12,000 ft.
- 640 Kbps downstream, 544 Kbps upstream for up to 17,000 ft.

ADSL speeds can vary greatly based on a number of conditions. In areas where there is a large variance in the length of the local loop (distance from the subscriber to the Central Office), the gauge of the wire, and the condition of the line, it becomes difficult to determine what speeds should be provisioned over each line. Its for these reasons that RADSL was developed and is superceding standard ADSL; Rate Adaptive ADSL allows automatic, or provider specified, adjustment of the speed on the line.

RADSL – Rate Adaptive Asymmetrical Digital Subscriber Line

RADSL stands for Rate Adaptive Asymmetric Digital Subscriber Line and offers a downstream (from CO or central site to residence) data rate of up to 7.0 Mbps and an upstream (from residence to CO) speed to 1.0 Mbps. Like ADSL, RADSL can use either Carrierless Amplitude Phase (CAP) modulation or Discrete Multi-Tone (DMT) modulation. RADSL technology automatically adjusts line speed based on a series of periodic tests that determine the maximum speed possible on a particular line. Since RADSL accommodates the maximum speed available across a particular line, much of the effort and/or guesswork can be taken out of provisioning ADSL. As with ADSL, RADSL supports both high-speed data and lifeline POTS service.

The primary difference between the RADSL-CAP and RADSL-DMT line cards is in the modulation technique used. The main difference between these two line coding methods is in determining the optimum speed between the CO and the residence/business over a single twisted pair of wire. CAP treats the entire frequency spectrum as a single channel and optimizes the data rate over that channel. DMT divides the bandwidth into sub-channels and optimizes the data rate for each sub-channel. CAP has been tested longer than DMT and more widely deployed and used, but DMT has been accepted as the standard by the American National Standards Institute (ANSI) and the European Telecommunications Standards Institute (ETSI). Currently CAP has been resubmitted to the standards process and it may be accepted as a second "standard."

Some of the advantages of RADSL are:

- Reduced loop qualification efforts
- Maximized service coverage
- Single product serves multiple applications
- Simplified deployment
- Reduced product inventory requirements
- Adaptability of data rate to changing loop conditions
- Bandwidth-based service offerings available
- Simplified service issues due to automatic rate adaptation

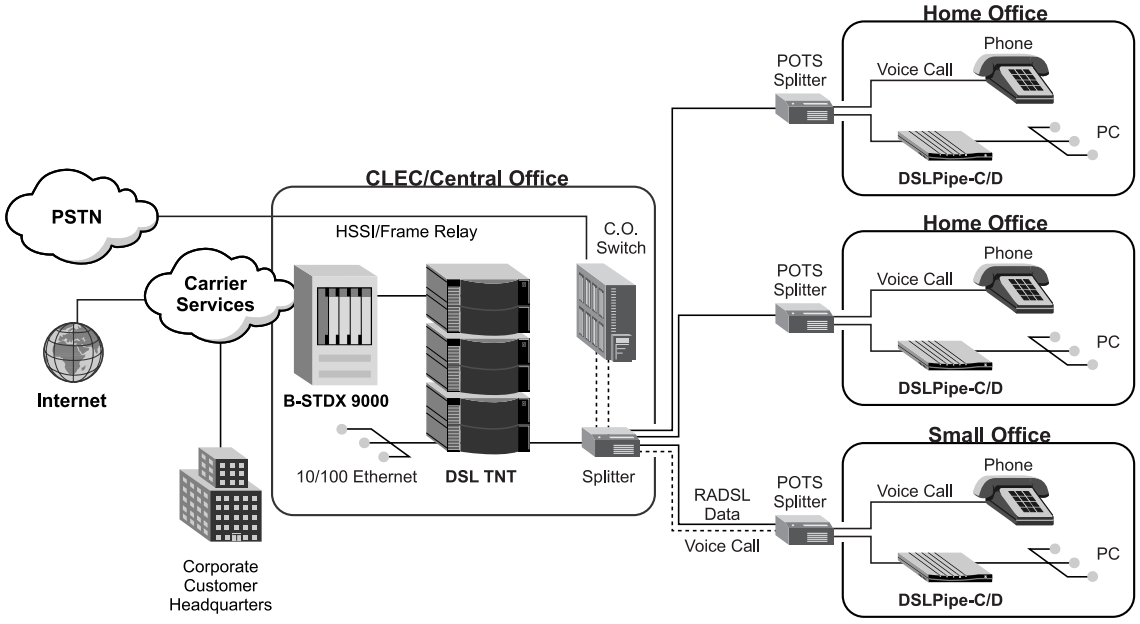

Figure 8 – RADSL provides the ideal solution for low-cost, high-speed Internet access for the residential consumer and business market.

RADSL-CAP:
Carrierless Amplitude Phase (CAP) modulation divides the spectrum into three parts; the voice band, the upstream communications band and the downstream communications band. The lower 4 Khz of bandwidth is the band utilized for regular analog voice transmission. Frequencies starting at 26 KHz are used for upstream data communications, and frequencies above 240 KHz are used for downstream data transmission. Downstream data rate is selected during the DSL initial configuration. At this time, the RADSL modem or router determines the highest data at which it will operate. With rate adaptive DSL the data rate can be automatically selected depending upon quality of a particular line, or set by the provider for different service options.

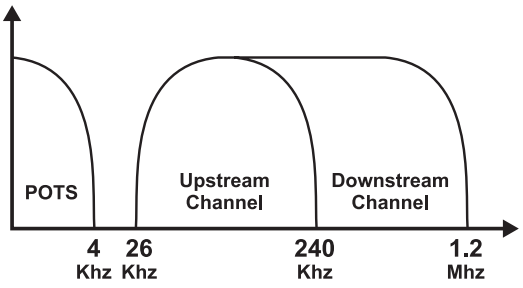

Figure 9 – Spectral distribution of RADSL CAP

RADSL-DMT:

The relevant standards committees (ANSI and ETSI) have approved Discrete Multi-Tone (DMT) technology for implementing broadband copper local loops to the home, and this same technology can be used with any telephone-grade twisted pair copper wiring. The DMT technique breaks up the available bandwidth into multiple subchannels and then modulates each band. Just as is done in CAP, the lower end of the spectrum is left alone for carrying the regular analog phone service. In ADSL DMT-systems the downstream channels from 26 KHz to 1.2 MHz are divided into 256 4-kHz-wide tones. The upstream channels spanning 26 KHz to 138 KHz frequencies are divided into 32 subchannels. Each subchannel is used as a carrier with bit and power allocations according to the signal to noise ratio characteristics of the subchannel. Thus, the link transmission is optimized by running each of the subchannels at best possible data rates.

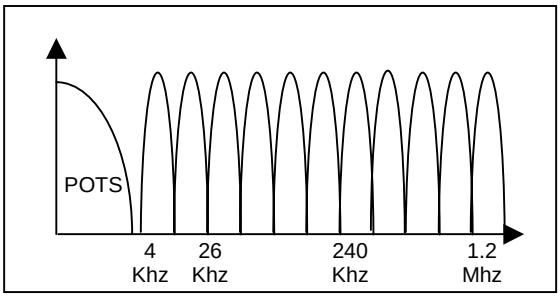

Figure 10 – Spectral Distribution of RADSL-DMT

VDSL – Very high data rate Digital Subscriber Line

Very high-bit-rate Digital Subscriber Line (VDSL) is an asymmetric solution that offers approximately eight times the performance of ADSL. At these high data speeds its reach is limited to a maximum of 500 to 1000ft on copper cabling. This technology is limited in its application as it requires fiber optic cabling to be used in the local loop so as to extend the range of this high-speed technology. Because significant telephone infrastructure changes are required in the local loop to accommodate the fiber cabling, VDSL is considered a specialized, future technology. VDSL may have specialized applications in non-central office copper environments.

3. The Opportunity: How You Can Profit From DSL

DSL technology delivers four compelling benefits. Specifically, it:

- Meets the rapidly growing bandwidth needs of both business and consumer markets
- Leverages the existing copper wire infrastructure to provide lower implementation costs
- Remedies congestion on the Public Switched Telephone Network (PSTN)
- Allows new companies to get into the business of providing very profitable high-speed data services

The unique advantages DSL offers over traditional analog services are its low-cost, high-speed and relatively long-distance communications over twisted pair copper wiring. Because DSL services utilize direct physical connections to both ends of twisted pair copper wiring, it is well suited for deployment in a broad range of applications by traditional telephone companies and any environment that has extensive copper wiring. RBOCs and regional independent telephone companies only slowly are beginning to adopt DSL technologies for their service. Fortunately, not all copper loops terminate in the RBOC's central office. Building owner/operators and campus environments where a company already has ownership or legal access to the entire length of wire are also very good applications for DSL technologies. For the first time the owners or managers of buildings, college campuses, government campuses and office complexes can easily begin offering high-value data services with significant profit, or cost-savings potential.

The Telecom Reform Act of 1996 broadens the DSL opportunity even more. It allows any company that meets the regulatory requirements access to unbundled copper loops between the RBOC's Central Offices and most homes and businesses. This opens up the additional opportunity for competitive access providers and ISPs to co-locate equipment in or near RBOC Central Offices as a point of entry for DSL-based data and voice services.

There are three general classes of copper lines and related DSL opportunities. In addition to the traditional "WAN Copper" opportunity for telephone companies, there is "Dry Copper", the unpowered local loop that competitive access providers can lease under the telecom reform act, and "Free Copper" that refers to all the installed copper phone wiring available today in buildings and campus environments.

"WAN Copper"

The expression "WAN Copper" refers to the huge installed base of copper "local loop" wiring between the CO and customers' residence or business. These copper wires, when used to deploy DSL technologies, offer the opportunity for significant advancements in Wide Area Network (WAN) data connectivity; thus the term "WAN Copper."

CLECs and Regional Independent Telephone Companies

1. CLECs – Currently, there are over 800 million telephone lines that exist worldwide between the Central Office and consumers. In the US these lines are, for the most part, owned and operated by the Regional Bell Operating Companies (RBOCs) but these local loops are now becoming available due to deregulation. While historically neither the need nor the technology of implementing high-speed, low cost, data communications between homes or businesses has existed, the market has changed dramatically in the past two years. There is now a compelling need for faster Internet access and full-time connectivity, and DSL technologies can provide services to meet this demand.

Six key market drivers make DSL technologies ideal for CLECs and Regional Telcos today:

1. **Internet Growth:** People around the world are rapidly adopting the Internet as a key personal communications tool and business resource. At the same time Internet web traffic is increasingly becoming multimedia in nature; complex graphics, audio and video are becoming common information sources available on the Internet. These two important trends are resulting in a rapid and insatiable demand for additional bandwidth to the home and business. Competition: RBOCs, competitive access providers and cable companies are moving quickly to offer high-speed data services. If the service providers want to maintain their lead in this market they will need to quickly deploy DSL services.

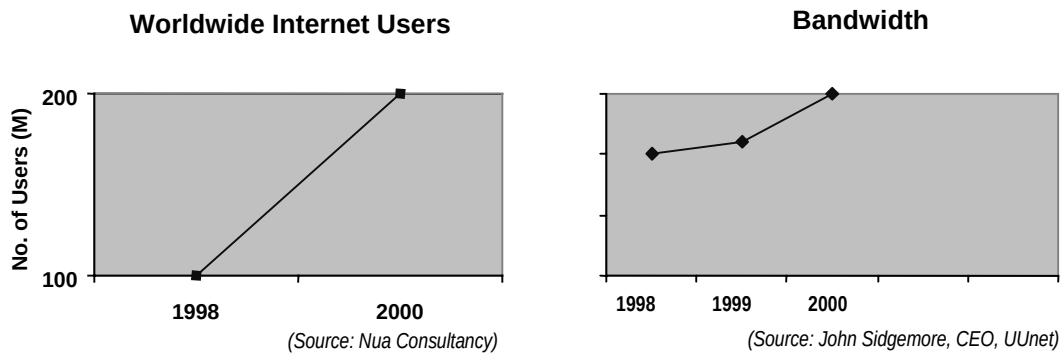

Figure 11 – Internet Growth Statistics

2. Competition: RBOCs, competitive access providers and cable companies are moving quickly to offer high-speed data services. If the service providers want to maintain their lead in this market they will need to quickly deploy DSL services.

3. Network Congestion: The Internet "explosion" has resulted in many more users making data calls over the Public Switched Telephone Network (PSTN). This has compounded network congestion while opening up the market for high-speed Internet access.

4. Call Length Increases: Reports filed with the FCC reveal that Internet service providers (ISPs) are significantly impacting the capacity of the Public Switched Telephone Network (PSTN). These studies also show that average phone calls by consumers for Internet access are 5 times as long (or greater) than the typical voice call and that T1 or PRI lines provisioned to ISPs average three to four times the load on a telephone companies lease to other businesses.

5. Provisioning Delays: Conditioning specific lines for traditional T1 circuits is both costly and slow resulting in expensive solutions that can take months to be installed. In the rapid-paced world of "Internet time" these delays are becoming increasingly unacceptable.

6. Infrastructure Demands: These higher traffic levels require a significant investment in the network for minimal return. These loads also increase the amount of Inter-Office circuits and equipment required and reduce the number of subscribers that can be supported per line unit and switch module. Upgrading central office switch capacity is an extremely expensive undertaking.

7. Customer Problems: Trouble reports and other indirect costs associated with switched circuit data calls have significantly increased, further reducing the traditional telephone company economics. Because DSL circuits are full-time, "nailed-up" lines, the support burden is anticipated to be significantly lower.

These issues, fueled by recent deregulation in the telephone industry, are motivating service providers to find alternate ways to quickly offer high-speed data services and at the same time reduce network costs, generate additional revenue and develop new service opportunities. To do so with minimal investment requires reuse of the existing telephone infrastructure with minimal modifications. Therefore, existing wiring loops, and any associated Subscriber Line Concentrators (SLC) and Digital Loop Carriers (DLC), must be utilized.

Telephone companies require a solution that alleviates the increased demands on the central office switched network while increasing speed and throughput. At the same time carriers must continue to offer traditional analog phone service (also called “lifeline POTS” or Plain Old Telephone Service).

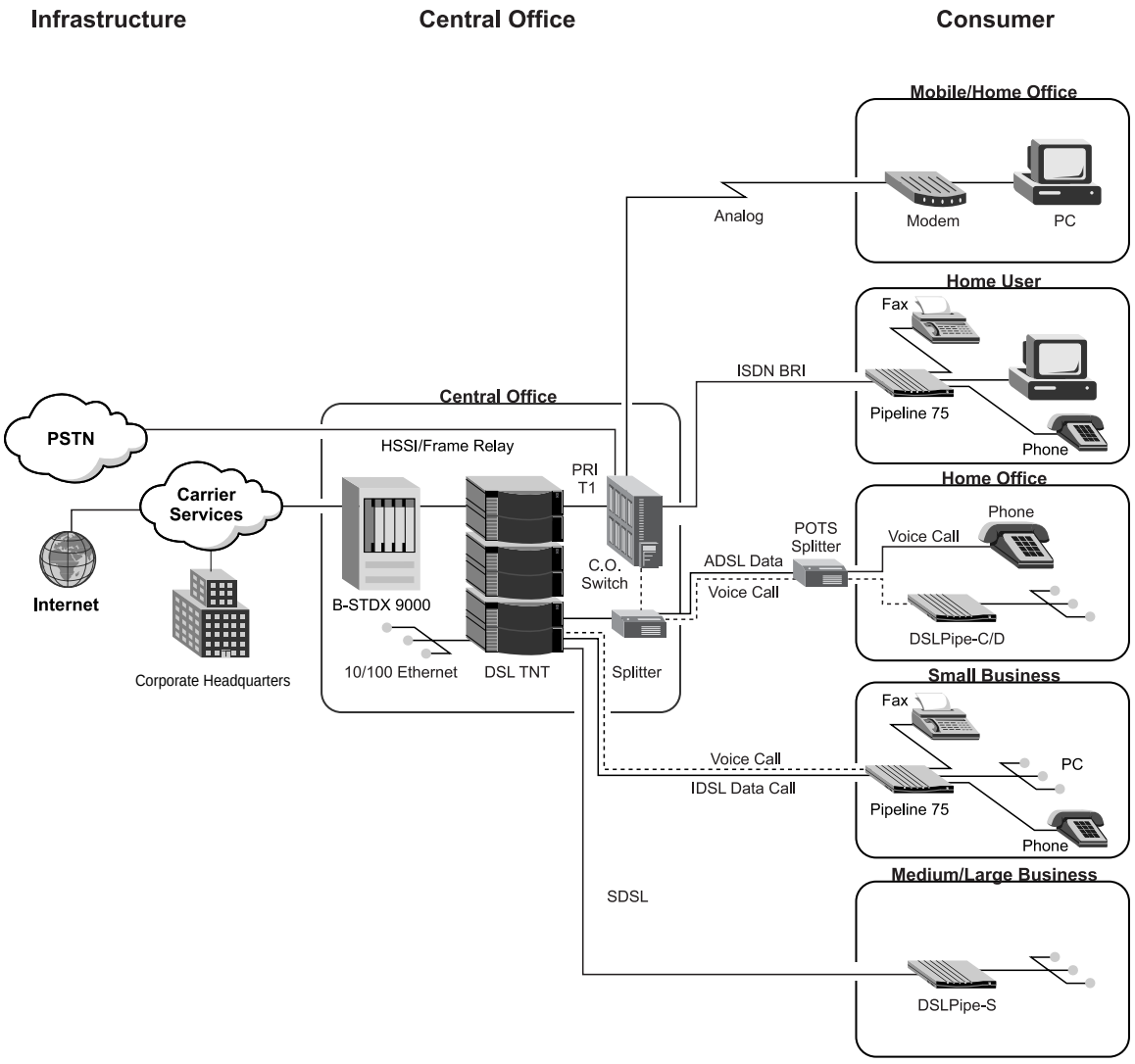

Figure 12 – DSL in a Carrier or Competitive Access Provider Application

To remain competitive while maintaining the high quality voice services and expanding their revenue base, competitive carriers have an opportunity to migrate the Internet data traffic from the traditional analog facilities to packet-based networks. New MultiDSL™ technologies available from Ascend allow carriers this opportunity. The MultiDSL products redirect data traffic to a packet-based network thereby circumventing the PSTN. Carriers can then provide additional data services that open up new markets and substantial revenue opportunities.

Regional Independent Telephone Companies

The Telecommunications reform act affects the entire telecommunications industry and not only the RBOCS. Many independent telephone companies are facing unprecedented competition in their service areas. But DSL opens new opportunities for these regional service providers.

DSL technology provides the chance for independent Telcos to enter new markets and offer cost-effective new services to existing residential and commercial customers. Historically to enter the digital circuit market telephone companies have had to pay for expensive ISDN upgrades to their central office switches. Additionally, line conditioners and local loop repeaters for the many longer local loops are also needed in many rural areas. These expenses may be difficult to justify for service providers that are unsure of the market opportunity for such services.

Ascend's NEBs-compliant MultiDSL allows the Independent Telco to inexpensively enter the lucrative data services market with minimal capital outlay, and without the added problems of circuit conditioning and repeater installation. At the same time DSL technologies allow the Independent Telco to off-load the data traffic which might otherwise travel over analog or ISDN BRI circuits through their voice switches, thereby allowing greater reliability and revenue growth in the voice business. Technologies like IDSL and ADSL also allow service providers to offer both voice and high-speed data services over a single telephone pair; thereby eliminating the potential added expense of installing additional local loops in sparsely populated regional areas.

Dry Copper

In the telephone industry the term "Dry Copper" refers to direct access to the unbundled local wiring loops terminated at the central office with no equipment attached to either end. Due to telecommunications deregulation this local loop dry copper is now available for lease by CLECs for new services. DSL technology is ideal for dry copper applications because of its ability to offer both high-speed data services (e.g. Internet access) as well as regular analog phone services, over the same pair of wires that users have traditionally used to offer only phone services.

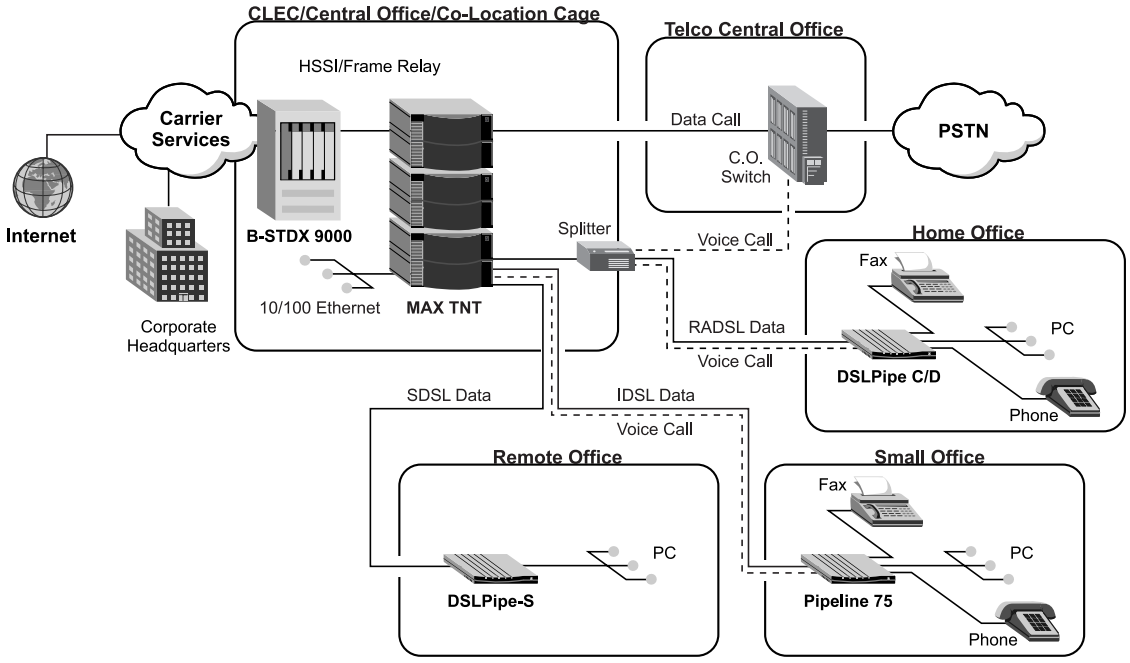

Figure 13 – A Competitive Access Provider can provide cost-effective DSL Internet access.

Competitive Access Providers (CLECs, Regional Independent Telephone Companies, ISPs)

While the Regional Bell Operating Companies (RBOCs) have an advantage with their direct access to local copper loops, most industry analysts agree that a large opportunity now exists for the fast-moving competitive service providers – the Competitive Local Exchange Carriers (CLECs), Competitive Access Providers (CAPs) and Internet Service Providers (ISPs). These competitive service providers can now gain full access to "dry copper" from the RBOCs, as well as through other sources of copper such as building owner/managers. Competitive access providers are already deploying DSL technologies and are expected to capture significant revenue over the coming three to five years.

Key factors in the rapid growth of the DSL service market with CAPs and CLECs are:

- Average local loop cost to competitive carrier: Approx. $15/mo5
- Average resale price of T1 (DS1) Circuit: Approx. $500 to $900/month
- Average price of Internet access via T1 Circuit: Approx. $400 to $600/month
- Average total SDSL port price (COE): Approx. $20/month (leased)
- Extremely high demand for high-speed digital circuits for Internet Access
- DSL Positive Cash Flow per SDSL port of up to $700 per month

In many metropolitan areas today it can take many months for businesses to have high-speed T1 lines installed. These delays are expensive and can interrupt regular business operations. With DSL technologies installed in office buildings and connected to fiber loops available in many cities, service providers can offer comparable bandwidth at a fraction of the cost and with delivery times that are far more responsive than what the RBOCs can deliver.

Free Copper

Free copper refers to the existing wiring that every building incorporates for the regular analog telephone services. ADSL, SDSL and IDSL technologies are ideally suited for this type of wiring. DSL allows building managers and the many other "free copper" owners to deliver high-margin data services for their tenants, or to partner with local Internet service providers or CLECs to address the internet access market opportunities.

Developers, High-rise Building Managers, Multi-Tenant Structures

The benefits of DSL technologies are not restricted to traditional telephone companies and competitive providers, in fact the biggest immediate opportunity exists for the large number of organizations that have control over their own copper wiring and who can easily utilize that wiring for additional services. Any business that has control over the copper wiring that runs between the floors of a building or between buildings on a campus can take advantage of DSL opportunities immediately. Typically this means that any building management company or any business that owns its own wiring or "cable plant" can quickly and easily implement DSL by placing a single concentrator in the wiring closet.

There are numerous ways in which building managers can benefit from DSL technologies:

- **Additional Revenue via Data or Voice Service offerings –** By installing DSL equipment in the telephone closet of a large building, and contracting with a local Internet service provider, building management companies are offering the high-speed Internet access that companies need. The monthly charges for such an installation can quickly pay back the original investment and provide a high level of cash flow and profits. (see Business analysis in section 7 of this resource guide). For building managers not interested in the development and maintenance of such a solution, opportunities exist to team up with a local service providers to install and manage the equipment in the building while both partners benefit.

[5] Business Communications Review, 3/97 pg. 69

- **Competitive Differentiation to Reduce Vacancy Rates, Charge Higher Rent –** With the unique benefit of high-speed Internet access as a differentiator for a building, owners can expect to reduce vacancy rates, demand higher rents and retain tenants. With the increasing importance of the Internet, the traditional delays by the RBOCs of provisioning high-speed telephone lines installed are no longer tolerable or necessary. Building managers can offer immediately available Internet services at competitive price to significantly differentiate their buildings.
- **Higher Selling prices of Condominiums and Houses, Rental Rates for Apartments –** Development Companies in and around major metropolitan areas (New York and San Jose for example) are already integrating high-speed DSL-based technologies into new apartment, condominium and housing developments to attract premium tenants. This high-speed Internet connectivity facilitates an important trend in the US towards greater "telecommuting" or working out of the home. It is expected that increasingly the communities around major metropolitan areas that have traditionally housed commuters will adopt high-speed Internet access to ease the travel requirements of knowledge workers.
- **Lower Cost of "Wiring" an Existing Building for Data –** DSL allows use of existing telephone wiring for data communications. This eliminates the need for expensive cabling installations or upgrades in buildings.

Alternatives to DSL

Traditional alternatives to DSL technologies for providing data services in buildings have been 10Base-T Ethernet Local Area Networks (LANs) based on twisted pair cabling, but there are many limitations to this approach. Key limitations of the LAN approach to providing building-based data services are:

- **Distance Limitations –** 10Base-T only supports 100 meters, or about 330 ft. vs. up to 18,000 feet for DSL technologies.
- **Shared vs. Dedicated Bandwidth –** Ethernet LANs are typically shared or bridged bandwidth – all the users have full access to all the bandwidth available. Ascend's DSL is based on a routed solution and every link is guaranteed access to its own bandwidth without competition from other users.
- **Security Problems –** LAN-based solutions, because they are typically shared mediums, are not secure and everyone on the LAN has potential access to other user's data. Ascend's MultiDSL solutions route traffic only to their destination and are therefore much more secure.
- **Availability Problems –** 10Base-T LANs are best operated over Category 5 twisted pair wiring; a level of wiring that is not available in many older buildings. In contrast, virtually every building has the standard copper telephone wiring that DSL technologies utilize.

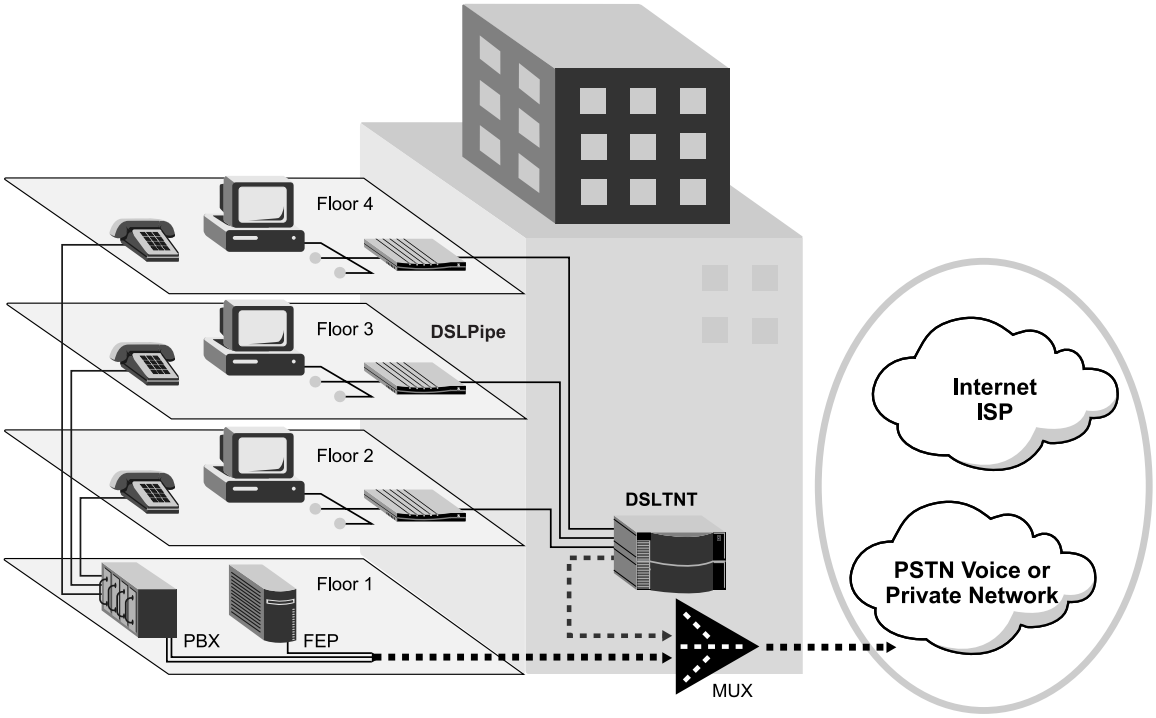

Figure 14 – A single DSL concentrator in a building offers high-speed Internet Access for Tenants of buildings on Fiber Net

Campus Applications

Universities and Colleges

DSL represents a very cost-effective means for universities, colleges and even hospitals and corporations to extend networks to multiple buildings spread out over larger campuses. Traditionally much more expensive approaches such as coaxial and fiber optic cables have been used, with the need for expensive backbone routers to manage the traffic. A DSL concentrator and inexpensive DSL routers at the remote location can provide many of the same capabilities provided by traditional coax and fiber networks but at a much lower cost per line. Often the copper phone lines already exist so no special cable installation or trench-digging is required.

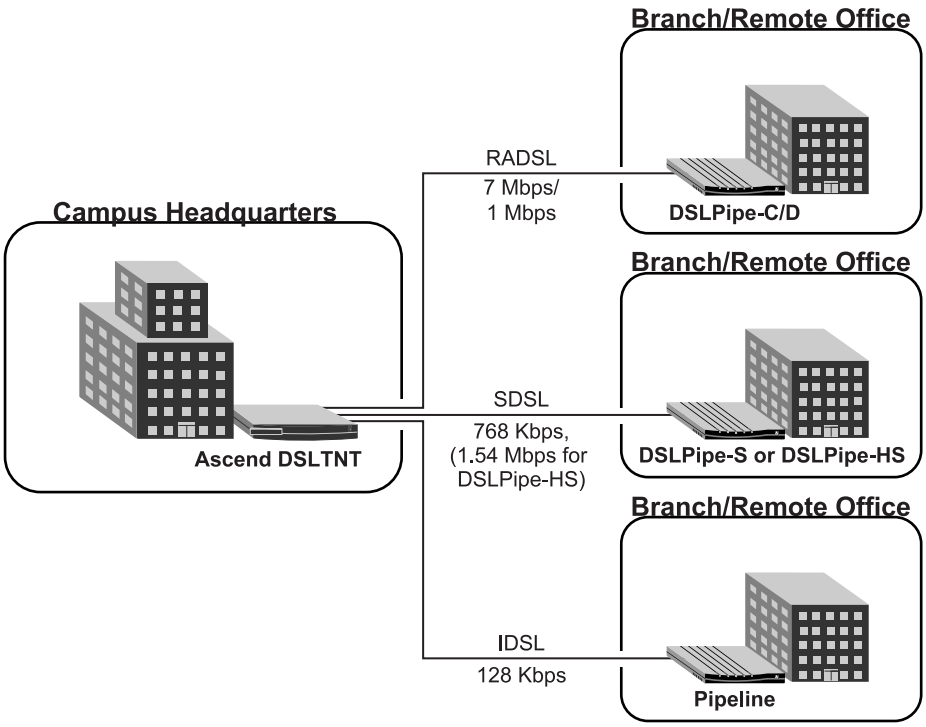

Figure 15– DSL application in a campus environment

Government Campuses

Just as with the university and college campuses, DSL represents a very cost-effective means for government campuses to extend secure networks to offices spread out over an area encompassing several square miles. Security options such as dynamic firewalls, VPNs and encryption are being utilized over these DSL lines to maintain a highly secure network. Ascend's DSL solution also provides security through routing, unlike some bridging solutions.

Nomadic Applications

Hotels and Airports

Hotels and airport management companies also have an immediate opportunity with DSL technologies to increase revenue. In a situation that is similar to the application of DSL in high-rise buildings, DSL offers hotels and airports the opportunity to gain additional revenue from the business people that are frequent users of their facilities. Just as Internet access has become a prerequisite for most businesses, so it is with many business travelers who need access to the same Internet resources while they are travelling. High-speed DSL-based internet access in Hotels and Airport lounges provides the potential for increased revenue from every visitor, as well as increased differentiation from competition. Companies hesitant to enter this market alone may partner with the traditional Service Providers who can provide the technical expertise needed for such an endeavor.

Kiosks and Malls

With Internet access becoming as important as telephone access there is increasing demand for Internet terminals in malls and other retail establishments. DSL provides the opportunity for stores and kiosks in malls to provide credit card based Internet access terminals.

In addition to the public market, mall owners have the opportunity to offer their tenants high-speed Virtual Private Networks (VPNs) that can be used to replace costly private data networks over leased 56 Kbps and fractional T1 lines. These VPNs can interconnect directly with the corporate headquarters, or provide Internet access.

Potential applications for DSL-based VPNs in malls include:

- **Uploading of Sales and Inventory Data –** Many tenants in malls are part of larger chains that have private data networks to upload sales data to a central office each night, or access central inventory databases to reconcile inventory accounts. Virtual private data networks provided using DSL allow much greater bandwidth at a fraction of the cost of a conventional private networks. At the same time DSL services differentiate a mall from its competitors, and results in lower total cost of operation for many of the stores that would otherwise have used leased lines for head office data communications.
- **Rapid credit card approvals over higher-speed VPN circuits –** instead of utilizing the slow, existing dial-up credit card authorization process, a much faster network-based solution could be developed.
- **Online training tools that could provide centralized, standardized training to all employees –** local stores could access the corporate intranet over the DSL network.
- **Bridal registry networks –** companies can share a centralized bridal registry service that is accessible by all the stores in the chain either over the Internet, or via a VPN.
- **Travel agent services –** Travel agents could utilize Internet resources as well as traditional proprietary networks in helping customers develop their travel plans.

4. DSL Applications

There are four broad target markets for DSL services:

- Medium/Large Business Markets
- Small Business, Telecommuting Markets
- Education, Government and Business Campus Markets
- Residential/Consumer Markets

Following is an evaluation of each market segment in further depth:

Medium/Large Business Markets

Medium-size or large businesses frequently require significant bandwidth for Internet access or for LAN-to-LAN internetworking. Internet access can be for employees that need to access competitive information on the web or collaborate with corporate partners via email, shared whiteboard, and even video applications. Internet access can also be for allowing access to an office's Web server by potential customers and partners. As companies get larger they frequently host their web servers on-site which can result in a balancing of Internet traffic – with large amounts of data traffic being inbound to access the web site, as well as outbound by employees accessing external web resources or communicating with partners and business associates. Additionally, increasingly companies are replacing private leased lines with Internet-based Virtual Private Networks.

While any DSL technology can be used for business applications, SDSL, or Multiple SDSL lines, may be an ideal solution for the applications with heavier bandwidth requirements. T1 lines have long been a standard in business applications and will continue to be for the immediate future. Ascend currently offers a remote site, or CPE router that supports two SDSL lines for a total bandwidth of 1.54 Mbps so the majority of business data services can be satisfied today.

SDSL Line cards can be installed in the MAX TNT and DSLTNT at the Central office, high-rise or campus to support up to 360 SDSL ports. In this application, end users can connect their Ascend's DSLPipe-S units or DSLPipe-HS units to the service provider's network. The connection speed is 1.544 Mbps over a twisted pair for a distance of up to 12,000 feet. SDSL is ideal data connectivity for smaller to medium size offices or businesses serviced by a regional telephone company, or campus offices or departments in a college or university setting. SDSL is also ideal for installation in high-rise buildings and office complexes where a building manager would like to offer high-speed Internet access to its tenants without having to lay new cabling.

Network service providers can fully address the business markets with Ascend's TNT-based DSL Solutions. In a single chassis, the Ascend MAX TNT supports RADSL for high-bandwidth asymmetric applications, SDSL for moderate bandwidth applications and IDSL for lower speed applications. In lower density applications the MAX 4000 series can be configured with IDSL modules to service 128 Kbps voice/data needs.

Small Business, Telecommuting Markets

Small businesses are similar in their communications needs to larger companies and while they typically have lower bandwidth requirements, any of the DSL solutions may be used to meet their needs. Smaller companies may use Web server services at their Internet Service Provider, or may host a web server at their own office and therefore require high-speed DSL services. The exact DSL service requirements will can only be determined by analyzing the amount of data traffic that may be traveling over these lines. If the company has few people and will use the bandwidth only for periodic web access and email then the company may be able to get by with only IDSL's data speeds. If the company has its own on-site web server or does frequent file transfers or is a frequent sender or receiver of larger files a higher speed DSL solution may be in order.

DSL technologies are also an ideal solution for telecommuting applications. DSL circuits combined with new Virtual Private Network technologies provide the bandwidth and security necessary for today's data-intensive file transfers. Just as with the smaller businesses, depending upon the type of communications and work being done by the telecommuter, any of the DSL technologies may be appropriate.

Education, Government and Business Campus Markets

DSL provides an extremely cost-effective means of interconnecting offices and buildings in a campus environment that already has copper phone wiring between its facilities.

DSL solutions can provide a variety of data services and eliminate the need for expensive fiber or coax cabling, and associated fiber or coax hubs and routers. In education, government and business campus applications most of the wiring will frequently be over relatively short distances and there will be fewer of the potential cross-talk and interference issues that the telephone companies run into. DSL services in most situations can be installed quickly over existing wiring at a fraction of the cost of other technologies that offer similar performance.

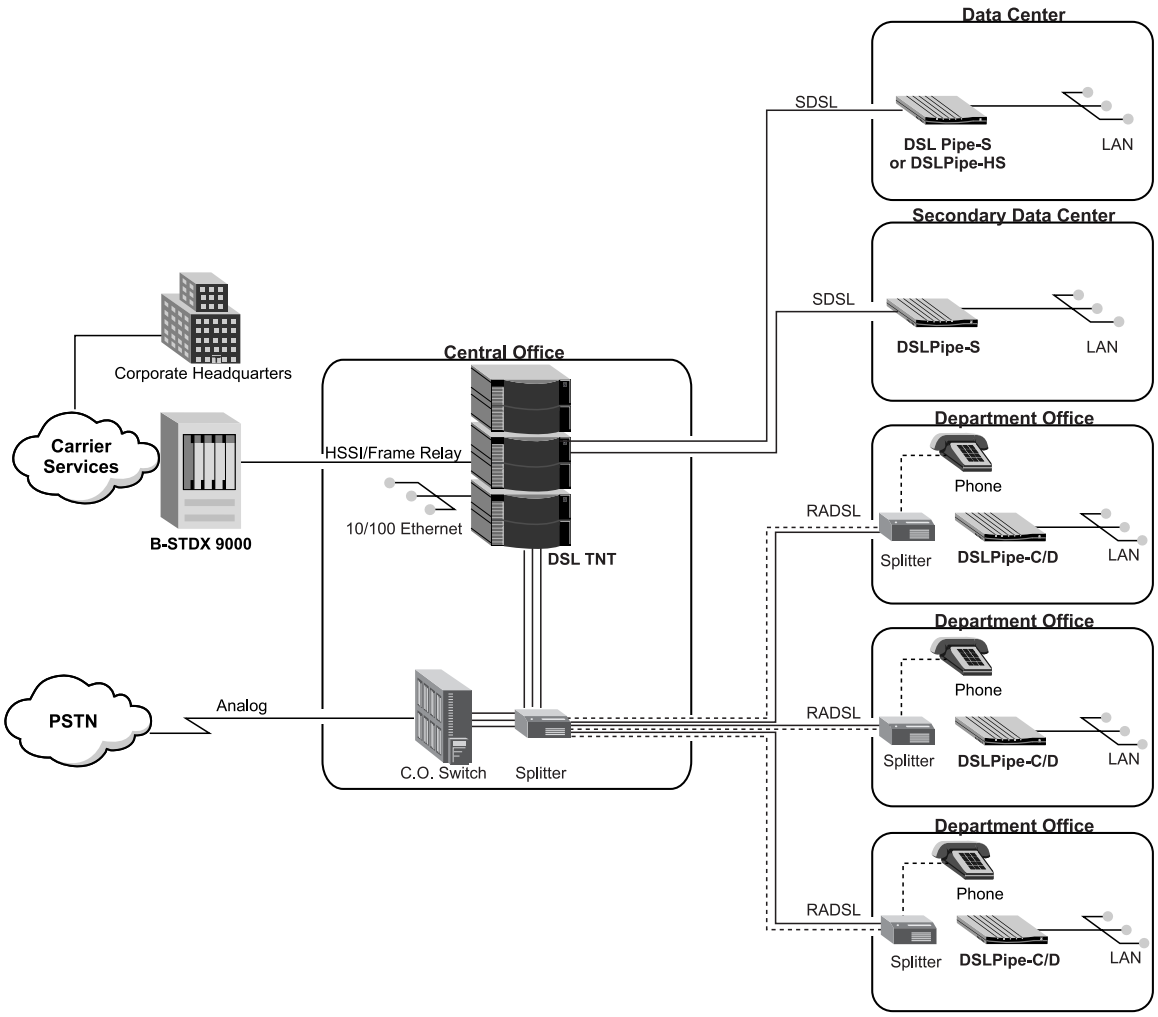

Figure 16 – DSL can provide low-cost, easily installed data circuits in campus environments.

Consumer Markets

Researchers estimate that over the next five years the consumer Internet market will continue to grow rapidly; to an estimated 78 million users by the end of 1997 and 268 million by the year 2001[6]. In addition to growing in number, increasingly consumers are expected to demand higher speed connectivity to eliminate frustratingly slow download times. At the same time people will use the Internet for activities that have traditionally been performed over dedicated or switched circuits – activities such as telephone conversations, teleconferences and videoconferences. DSL provides the cost effective means to meet these additional demands.

Given these requirements, and the need for lifeline telephone service, (also called Plain Old Telephone Service, or POTS) support, RADSL is expected to be the most common choice for consumer DSL applications. Only RADSL offers the high bandwidth of 7 Mbps or more down to the consumer to handle the large graphics and video files. This asymmetry of the RADSL service also helps to differentiate this high-speed Internet access solution from lower bandwidth but higher priced services that are targeted at business customers.

In late 1997 a new DSL standard called DSL Lite was initiated by Microsoft, Intel and Compaq Computer. Ascend fully supports this new consumer-oriented DSL standard.

Vertical markets

The DSL services opportunities can also be viewed from the perspective of vertical business segments that frequently demand high bandwidth or have to hire the services of traditional transportation services such as courier or express mail services to transfer digital media.

In addition to the aforementioned horizontal market segments for DSL, there are a number of vertical markets that are demanding the high bandwidth that DSL services provide. These vertical markets include:

- Graphics-oriented businesses (e.g. service bureaus)
- Media Business (e.g. Multimedia development companies, film studios)
- Hospitals with medical imaging applications
- Distance Learning
- Videoconferencing Service Bureaus

Applications by Service Provider

DSL can also be classified by the type of service provider. Following is an outline of how each of the major provider types can approach the DSL market and offer DSL-based applications.

RBOCs and Regional Independent Telephone Companies

Regional Bell Operating Companies can address both business and consumer markets with Ascend's TNT-based DSL concentrator and modules. In a single chassis, the Ascend MAX TNT and DSLTNT meet a broad range of data networking needs; from lower to moderate speed symmetrical applications with IDSL and SDSL, to higher speed asymmetrical applications with RADSL. The MAX TNT and DSLTNT offer the highest DSL port densities in the industry per 7-foot rack; up to 1344 IDSL ports, up to 2160 SDSL ports, up to 540 RADSL CAP ports. In lower density applications the MAX 20XX/40XX/6000 series can be configured with IDSL modules to service 128 Kbps voice/data needs.

[6]Dataquest August 1997 Internet Growth Report (Reported in Netscapeworld.com)

Infrastructure

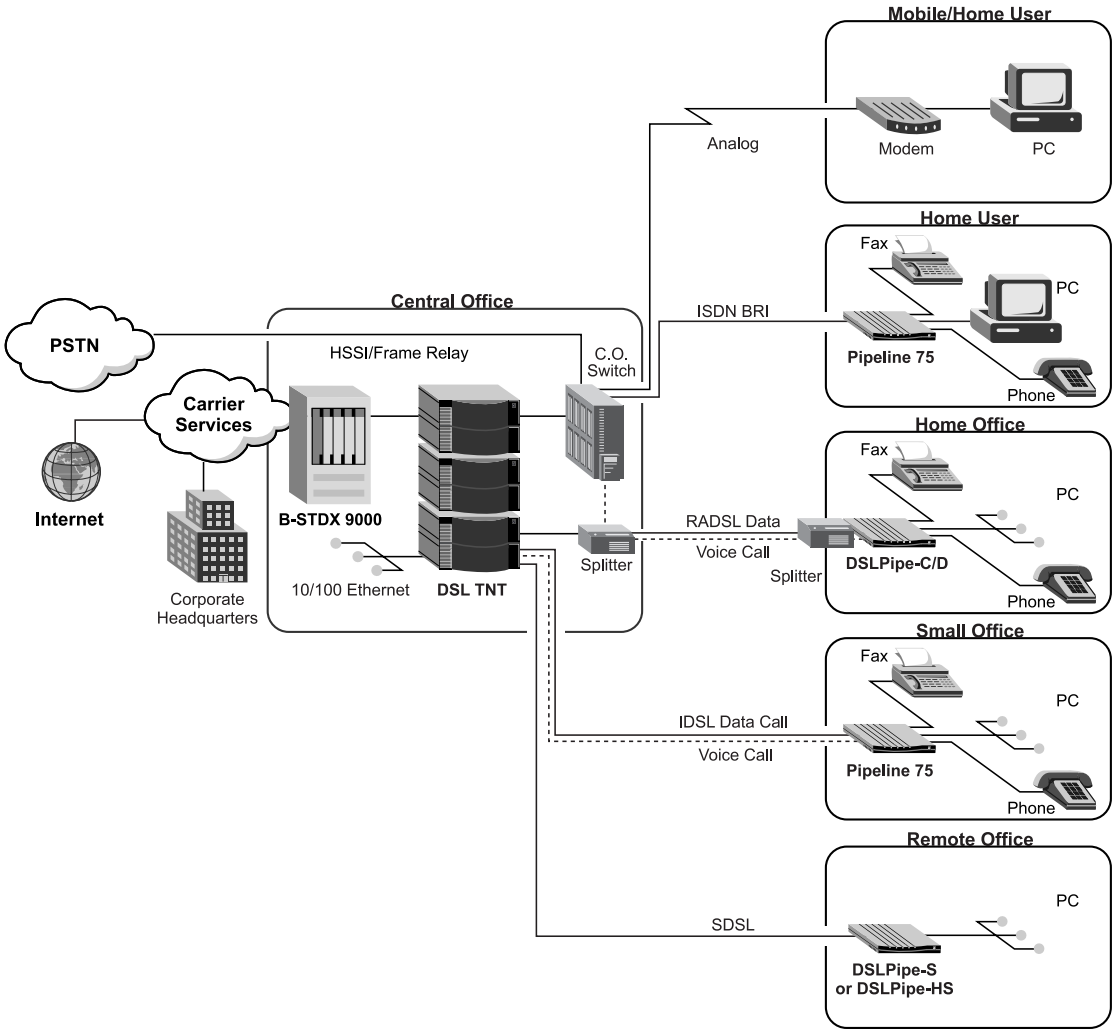

Figure 17 – Ascend MAX products provide comprehensive DSL solutions for Carriers and CAPs

Independent Telephone Companies – Addressing the Business and Home Markets

DSL technologies offer service providers inexpensive access to new revenue opportunities both in the consumer and business markets. Increasingly Independent Telcos are seeing demand from both consumers and businesses for higher speed data services and second or third telephone lines as people turn to the Internet for information, and start businesses from home. Ascend's DSL technologies can provide ideal solutions to these needs.

Additionally, in many regional Telco networks the local loop has either "U" loop repeaters and/or Digital Loop Carriers (DLCs) to handle the longer distance between the Central Office and the remote customer premises. As a result, independent telephone companies are looking for ways to offer data and voice over a single pair of wire without changing the existing "U" loop repeaters and DLCs. Ascend's IDSL products deliver exactly what these independent telephone companies are looking for.

Ascend's IDSL solutions also allow companies to offer ISDN-like services while avoiding the high costs of making a central office ISDN-ready. For traditional ISDN services Telcos need an expensive software upgrade to their digital switch. Ascends DSL products can offer the high-speed data service and a single analog phone circuit at a fraction of the cost of upgrading a central office switch.

Additionally, instead of simply providing raw bandwidth in the form of T1 or fractional T1 circuits, Independent Telcos can easily get into the value-added network business with high-speed Internet access and related services. Just as with the RBOCs, SDSL and IDSL technologies offer cost-effective business solutions for Internet or private network access.

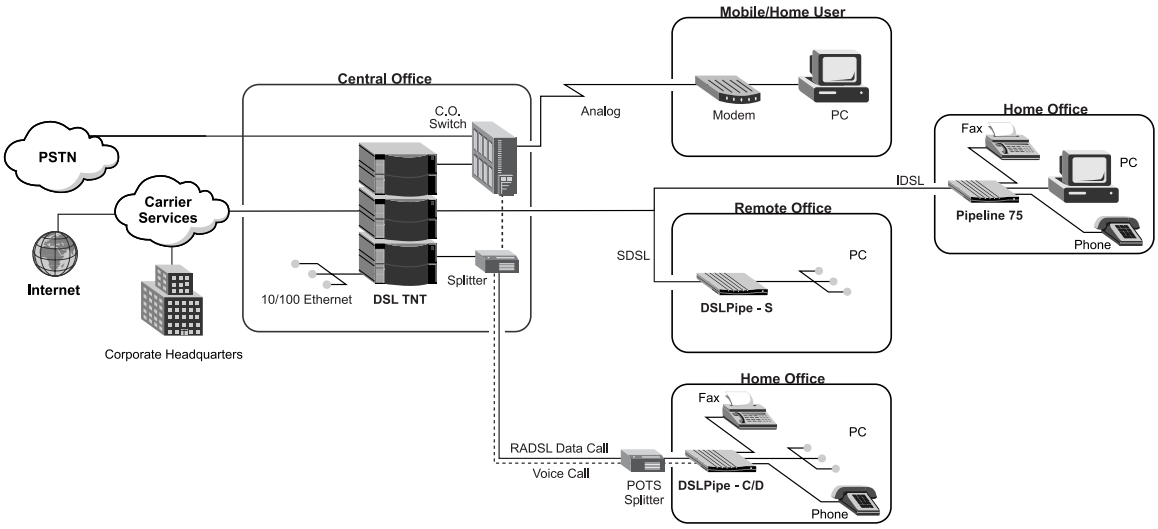

Figure 18 – Ascend's IDSL, SDSL and RADSL solutions can provide cost-effective Internet access and voice services to rural customers.

Competitive Access Providers, CLECs, and ISPs

CLECs and ISPs can quickly expand into the major market opportunities using Ascend's DSL technologies available today. The largest immediate opportunity for competitive access providers is in providing high-speed Internet or network access in the form of SDSL-based services to the corporate market. A recent study in Business Communications Review[7] magazine revealed that approximately 1.5 million branch office locations in the US currently do not have T1 service, mostly because of price. The study stated that the primary barrier to realizing the demand was the high price of T1 services, currently averaging $900/month. The study stated that "The optimum price for T1 connectivity was $450/month – at that price there were 900,000 penetrable sites and that would create a massive market shift." CLECs can utilize SDSL to provide low cost equivalents of T1 or Fractional T1 data service to businesses.

Telecommuters in these same business markets will also be early adopters of DSL technologies and many companies will subsidize employee network services so there is even greater pricing latitude when servicing this market.

[7] Business Communications Review, March, 1997

In addition to targeting the traditional large companies located in the Central Business District of a city, service providers can target any of a number of high-bandwidth vertical market opportunities such as graphics service bureaus, multimedia and electronic media development companies, or branch offices of businesses that could use a VPN to replace existing leased lines.

The consumer markets in major metropolitan areas also include high numbers of sophisticated Internet users that will pay premium prices for high-speed Internet access so these too are a good market for DSL technologies.

Competitive Access Providers (CAPs), CLECs and ISPs can also leverage the Telecommunications Act of 1996 to enter the local regions and expand into voice market for additional revenues. Penetrating the voice market can be simplified with Ascend's DSL technologies that support voice and data can allow network service providers to start with only data services and then grow into the voice market when appropriate, using the same DSL lines that they already have installed. Dualstar Technologies Corporation (www.dualstart.com), a Manhattan, NY-based company, is just one example of a number of companies already leveraging Ascend DSL products to enter the telephony market.

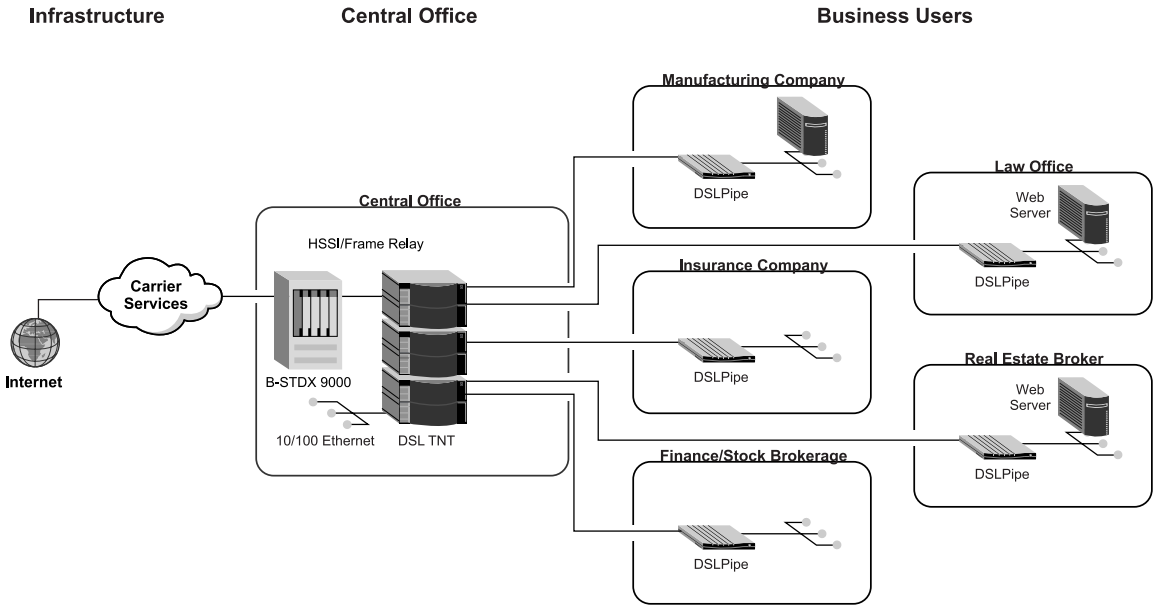

Figure 19 – Competitive Access Providers can cost-effectively service business and consumer markets with Ascend's DSL options.

These opportunities are already starting to be addressed by the early adopters of DSL technology, and with considerable success. Dakota Services in Milwaukee, Inc based in Chicago, and Lighthouse Communications, Inc. in Iowa are just three ISPs that are already leveraging Ascend's DSL solutions to provide business Internet access from Central Office co-located DSL equipment.

Campus – University/College and Government/Military Applications

Campus applications are ideal opportunities for DSL solutions because of the simplicity of the twisted pair cabling network (compared to the Telco network), the complete ownership or control of the cabling plant, and lower potential for cross-talk from sources such as traditional Alternate Mark Inversion (AMI) based T1 circuits. Additionally, educational institutions are frequently very cost sensitive and DSL solutions can provide unparalleled cost effectiveness. Campus DSL applications offer the opportunity for quick implementation of DSL networks that eliminate the need for costly coax or fiber connectivity and routers between buildings.

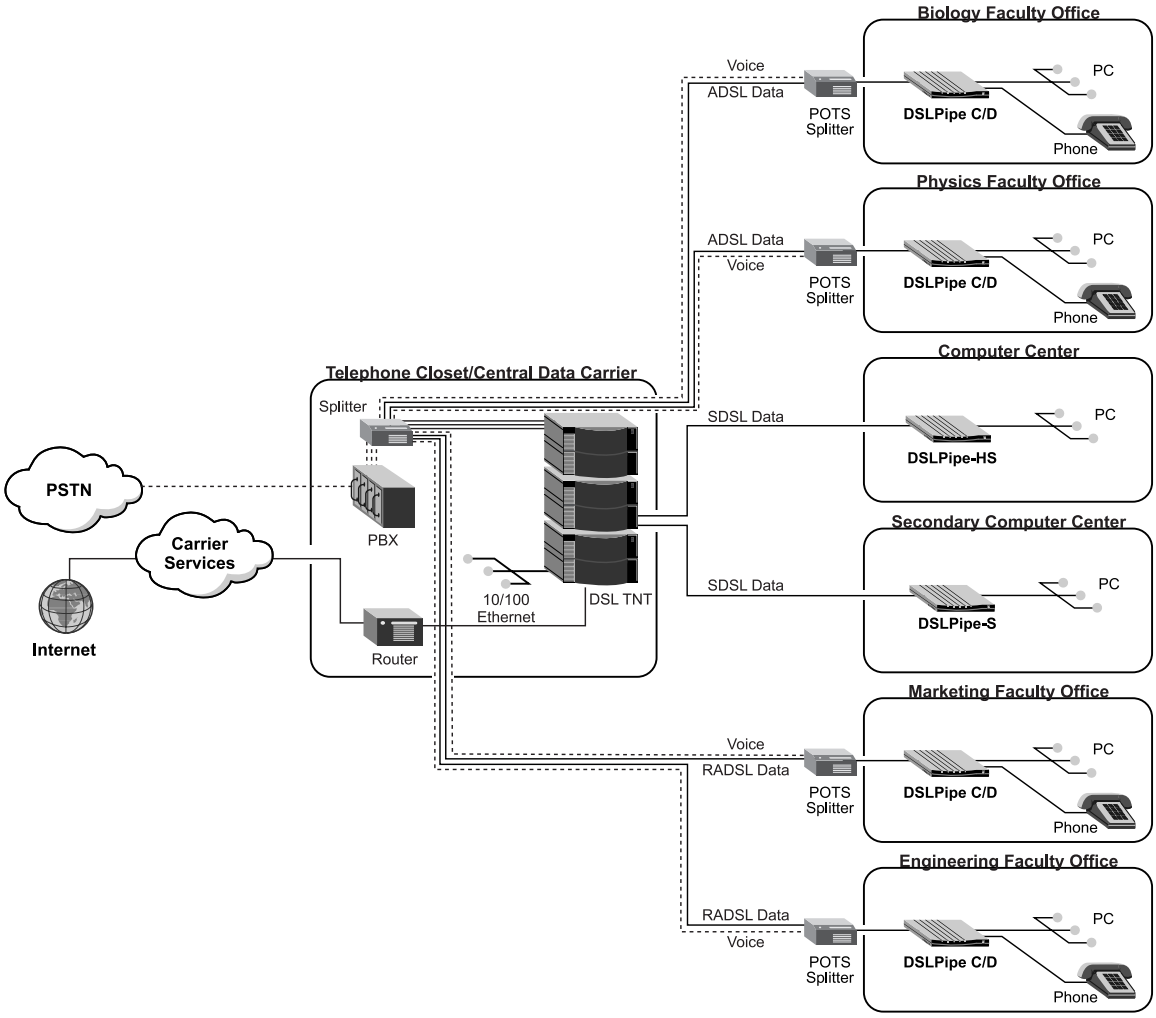

Figure 20 – Campus DSL Application

Shared Tenant

Shared tenant locations offer an excellent opportunity for rapid payback applications of DSL technologies. Just as with the campus applications, shared tenant applications offer the benefit of relatively simple wiring networks, fewer potential implementation issues, and quick access to the copper wiring and telephone closets. Partnership with a local ISP or CLEC for management of this service can further simplify and speed the implementation of such a service.

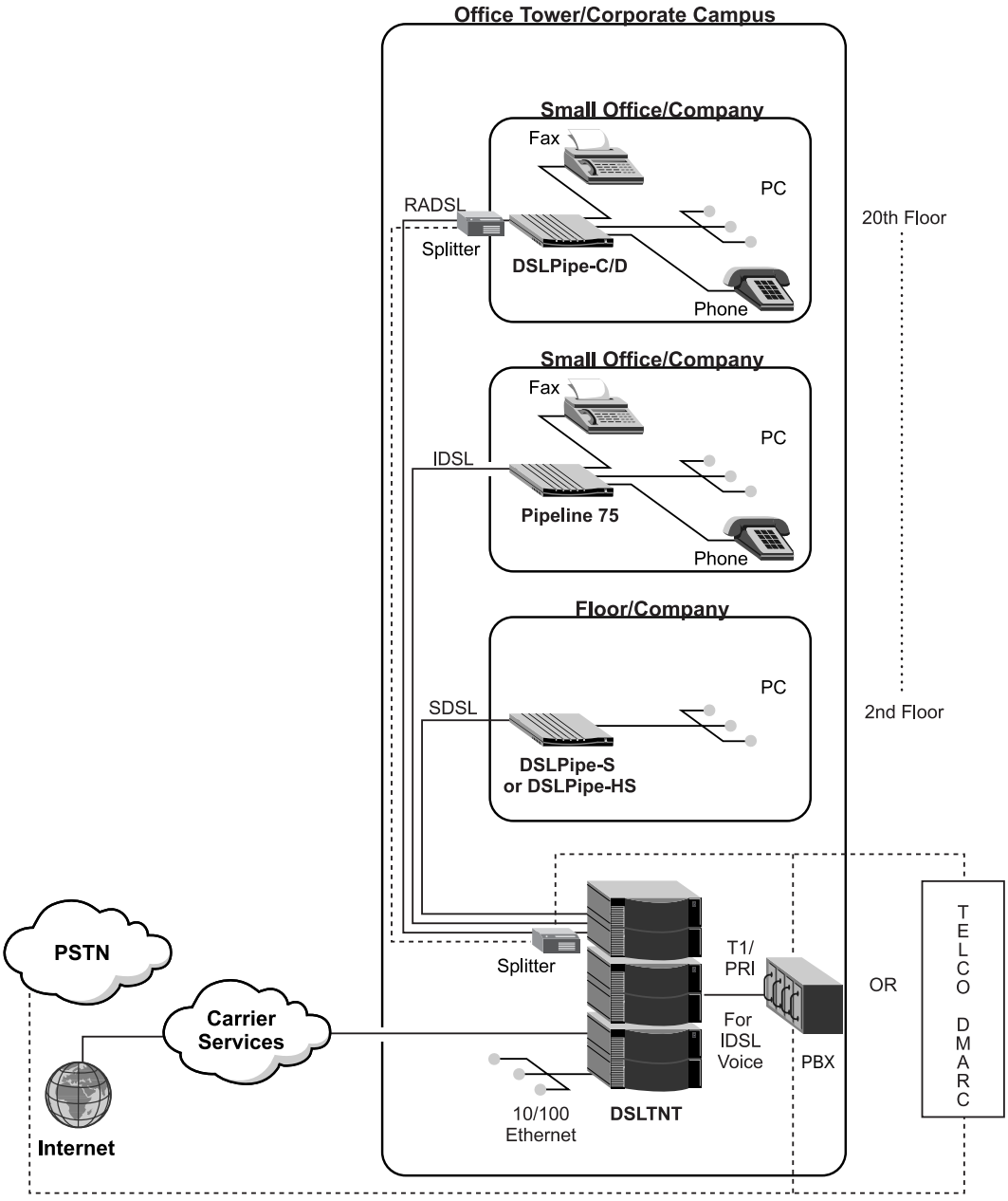

Figure 21 – Shared Tenant DSL Application

There are a number of shared tenant opportunities that are relevant for DSL:

- **Apartment Buildings –** DSL technologies allow building owners to capture greater revenue from every tenant. Internet access is becoming so common that soon it will be similar to power and water service in its ubiquity. Unlike power and water, DSL Internet services can easily be offered to tenants as a value added service that differentiates a building from others in the neighborhood.
- **Condominium/Housing Developments –** With the rapidly increasing frequency of telecommuting and high-speed Internet access, Condo and housing developments are increasingly providing high-bandwidth DSL services such as IDSL, RADSL or SDSL directly to home-offices. These services differentiate the housing or Condo development and can be used to justify higher prices.

- **Office Buildings –** DSL services for Internet access represent a large and immediate revenue opportunity for building owners and partners such as CLECs and ISPs. By placing DSL concentrators like the MAX TNT and DSLTNT in the telephone closets of large multi-tenant buildings companies can quickly begin offering Internet access services that are becoming the lifeblood of new business opportunities. In the past office complexes have differentiated themselves based on location and quality of amenities. In the future these same office complexes will compete in the quality and speed of Internet services they offer to their tenants.

Nomadic

Hotels

Just as value added services such as movie rentals and room service provide significant added revenue to a hotel, so will high-speed Internet access add revenue and profits in the near future. Any hotel addressing the business travel market can use DSL Internet services to differentiate themselves. It is well known that most business travelers now carry portable computers with them, and these same business travelers frequently need connectivity to their corporate networks while traveling to obtain email, or download files left on the office computer. At the same time there is the problem that if hotel guests use the regular analog line for these file downloads the phone can be busy for a long period of time when person might need to receive calls. DSL technologies allow hotels to inexpensively offer data services or Internet access to customers over existing telephone wires while still providing standard phone services.

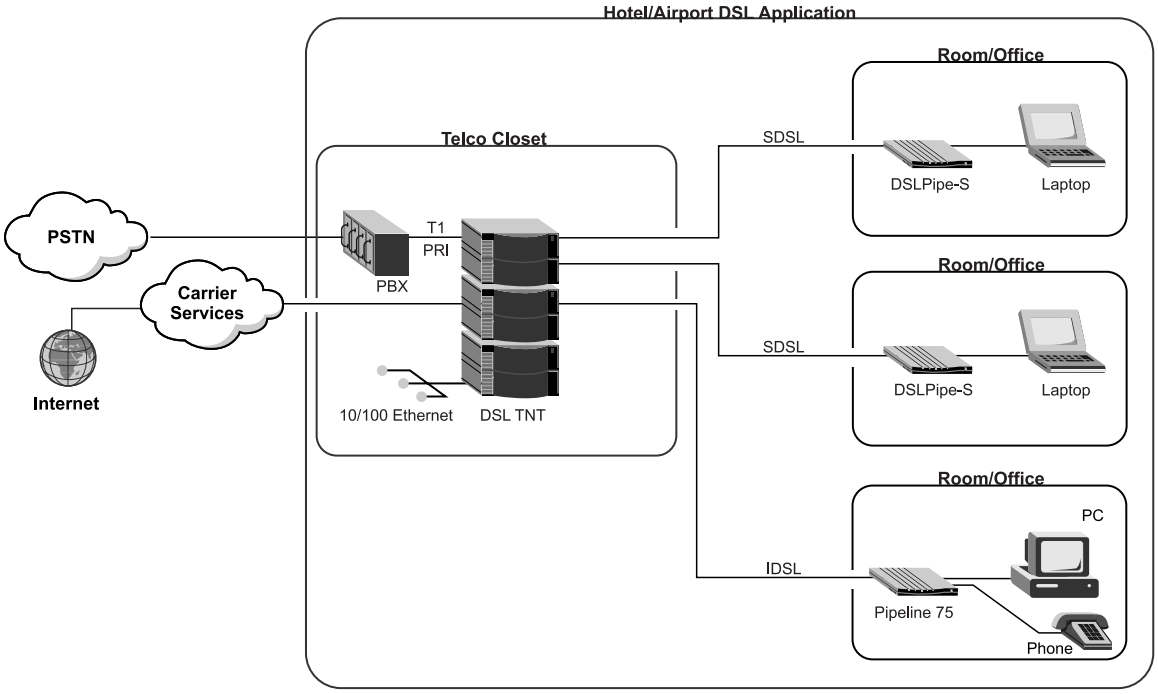

Figure 22 – DSL-based Internet Access can differentiate hotels and Airport sites while providing significant additional revenue.

For simplicity, hotels could charge a flat fee for Internet access during a customer's stay, independent of traffic, much as many Internet service providers do. Already leading computer companies like Compaq Computer, Inc. are expected to announce that they will be bundling DSL modems with some versions of their desktop computers. These computers could be offered in hotel rooms for rental much like TVs and movies are offered. Other hotels may choose to equip their business services offices with DSL just as they currently provide copying, fax and express mail services.

Airport Clubs

Airport clubs can easily expand their business traveler services and differentiate themselves from the competition by adding high-speed Internet connectivity, as well as Internet kiosks for web access for those without their computer.

Kiosks and Malls Tenants

Kiosks: Internet-based mall information services – for shoppers within the mall and for potential customers who are at home searching for information about a mall and its stores.

VPN for tenant data networks

Large “Anchor” tenants such as a major clothing retailer, as well as local stores that are members of a national or regional chain all have significant data communications needs between the local store and headquarters. Currently these communications take place over dial-up circuits, or leased lines. In the future these can be part of a mall’s infrastructure that attracts tenants just as exterior design and location do.

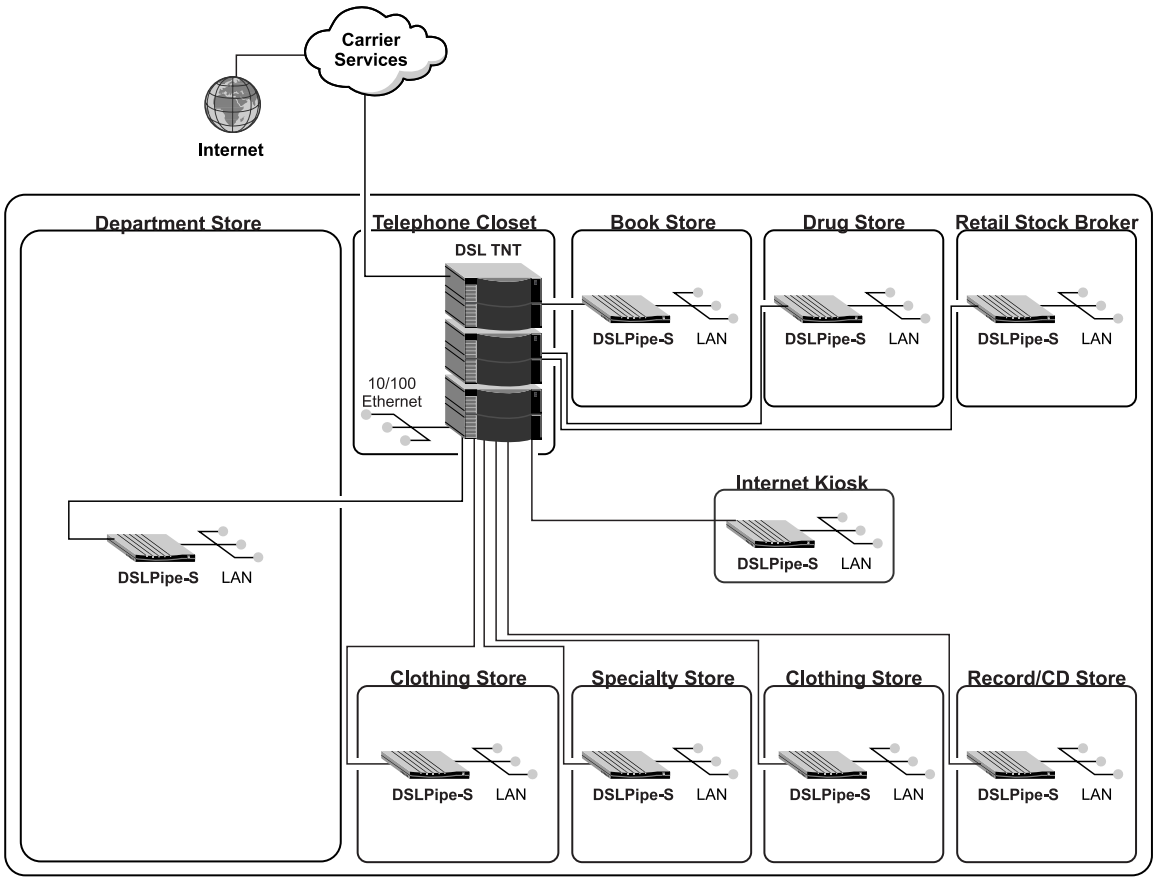

Figure 23 – DSL can provide valuable networking services to tenants, shoppers and prospective customers

5. DSL Equipment Overview

There are two general classes of DSL equipment; Central Site (typically located in a Central office, ISP POP or Building Telephone closet) and Remote Site (located at the customer's site or office). Within these two classes there are further divisions of product type. In the central site solutions there are generally two types of equipment; the multiplexer/bridge equipment and the Access Router/Switches. There are also two general product types in the remote site market also; DSL modems/bridges and DSL Routers (also called Customer Premises Equipment).

Central Site Equipment

DSL Multiplexers and Access Routers

DSL multiplexers or bridges are frequently based on Asynchronous Transfer Mode (ATM) and offer a bridged solution at the packet level (Layer 2). These can be inexpensive access solutions as standalone products, but generally require an expensive ATM switch and IP (if accessing the Internet) router in addition to the DSL multiplexer/bridge.

DSL access routers/switches frequently provide DSL services based on Frame Relay or Point-to-Point Protocol (PPP) and offer Layer-3 routing between the customer site and network. As standalone products these Access Routers may be more expensive than the stand-alone DSL bridges but they may not require an ATM switch or additional IP router.

Remote Site Equipment

DSL Modems and Routers

DSL modems are customer premises equipment that provides basic DSL connectivity between the remote site and the central site. With minimal intelligence and computing power these devices typically offer low-priced connectivity for a 10Base-T LAN and provide basic bridging of packets between the remote site network and the remote network (or Internet). All traffic of any protocol type that has a destination for the remote network is automatically forwarded to the remote network – including all broadcast traffic, and even IPX traffic – even if the DSL link is only for IP connectivity. Basic filtering of packets is possible based on source and destination address, but filter management is typically quite challenging.

DSL Routers are very similar to existing ISDN or Frame Relay routers in that they typically offer IP or IPX routing between a 10Base-T LAN and a WAN link; a DSL WAN link in this situation. Only the packets that are of the correct protocol type and destination address will be forwarded across the DSL link.

6. Ascend's DSL Product Line

Ascend offers the most complete selection of DSL equipment available on the market today. Only Ascend can provide solutions that can easily accommodate a range of DSL technology based on a proven line of access concentrators that meet all a service provider's low, moderate and high-speed DSL access solution requirements.

Central Office Equipment (COE)

Ascend offers a comprehensive range of DSL products for the central office or POPs, and customer premises. The MAX DSLTNT, MAX TNT, MAX 20XX/40XX/6000 products deliver the multiprotocol, multiservice capabilities that are required at the central office of the carriers and service providers. Ascend's Digital Subscriber Line cards are supported on the MAX 20XX/40XX/6000 and MAX TNT WAN access switches. The support of these line cards ensures that the MAX 20XX/40XX/6000 and MAX TNT products continue to offer the next generation of high-speed services from carriers and service providers. These services may be Internet access, remote office connectivity or telecommuting – applications that demand high bandwidth. Support of both PPP and Frame Relay protocols in the MAX products ensure greater flexibility and investment protection for both carriers and subscribers.

DSLTNT

The DSLTNT is a full-integrated multiservice xDSL concentrator. Its powerful combination of enterprise-level scalability with carrier-class robustness that provides the complete integrated DSL access solution. With support for up to 360 SDSL, or 224 IDSL, or 90 ADSL circuits the DSLTNT allows network service providers to service a broad range of consumer and business customers from the same high-capacity DSL concentrator. The DSLTNT offers the highest port densities and the broadest range of access technologies available on the market today. The DSLTNT also supports Layer 2 multiplexing support, enabling carriers to easily offer plug-and-play solutions with end-to-end multiprotocol DSL transport. The DSLTNT is also certified NEBS level-3 compliant, which means it, complies with the rigorous requirements for central office operation in global carrier networks. DSLTNT also fully supports DS-3 (45Mbps) access circuits for high-speed interconnectivity with the Internet backbone.

MAX TNT

The TNT is a powerful WAN access concentrator that provides the complete high-capacity solution. With support for up to 720 DS0 circuits and the full range of access technologies, including DSL, T3, T1/E1, ISDN and analog. Fully compliant with existing network infrastructures, authentication standards, and SNMP management protocols the MAX TNT was designed to be the ultimate in integrated access switches.

The MAX TNT has a scalable, modular card and backplane architecture that provides access to the Internet or global corporate network services. The modular card system lets users design a solution that satisfies the specific application and bandwidth requirements of any customer from medium density corporate LAN access needs, to large central office "MegaPOP™s".

MAX 6000

The MAX 6000 is a new mid-range model in Ascend's line of WAN access switches with support for up to 4 T1s or 4 E1s worth of IDSL, modem or ISDN traffic. With a high-speed 64Mhz i960 RISC processor, and six expansion slots that support IDSL as well the broad range of traditional analog access modems and new MultiVoice Voice over IP solutions. NEBS Level-3 compliance, and a Bellcore-recognized Mean Time Between Failure (MTBF) of over 500,000 hours makes the MAX 6000 an ideal access platform whether installed in the Central Office, or a telephone closet.

MAX 4000

The MAX 4000 is the mid-level WAN access switch of choice for International ISPs and network service providers, large corporations, and telephone companies. The MAX 4000 comes fully configured with support for all international signaling standards for support of up to 4 T1/E1/ISDN PRI lines. Because it is designed for the International market there are no built-in CSUs in this product as there are with the MAX 4002/4 products.

- Support for analog, ISDN PRI, ISDN BRI, IDSL, switched services and Frame Relay over 4 T1/E1 lines
- Six expansion slots for add-in option cards
- Global Digital Access Software Option – enables PRI signaling for network interfaces
- Expandable with optional BRI cards
- SecureConnect Firewall software option – provides integrated dynamic firewall protection on all WAN access ports
- Expandable with optional IDSL cards for support of digital subscriber loop technology

MAX 4002 and 4004*

The MAX 4002 and 4004 are flexible, open-configuration products that are ideal solutions for medium-size network service providers. The MAX 4002 comes pre-configured with 2 operational T1 interfaces (with integrated CSUs) and six open slots in the chassis for optional cards (the MAX 4004 comes preconfigured with 4 T1 interfaces with integrated CSUs).

Multiple MAX chassis' can be installed in a POP and with the MAX Stack software (standard with every MAX) these multiple chassis' can act, and be managed, as though they were a single chassis.

The MAX 4002 and 4004 and have the following options available for them:

- Support for analog, ISDN PRI, ISDN BRI, switched services and Frame Relay over up to 4 T1/E1 lines.
- Frame Relay Software Option – enables Frame Relay support
- Global Digital Access™ Software Option – allows digital connections
- Secure Connect Firewall software option – provides integrated dynamic firewall protection on all WAN access ports.
- Expandable with optional IDSL cards for support of digital subscriber loop technology

* for US applications only

MAX 20XX

The MAX 20XX is the low-end WAN access switch of choices for service providers and enterprises. The MAX 20XX comes pre-configured with a T1/E1 interface.

- Supports for analog, ISDN PRI, ISDN BRI, IDSL, Frame Relay
- Two slots for IDSL or modern cords
- Global Digital Access Software Option

IDSL line card for MAX 4000, 4002 and 4004

The IDSL Line cards offer eight ports per card and up to five cards per MAX 4000, 4002 and 4004, for a total of up to 40 IDSL ports. Each IDSL port supports a 128 Kbps digital connection to subscribers and connects end users' (third party) ISDN terminal adapters, Ascend's Pipeline, and IP application software. An HDLC controller card is required if more than four IDSL cards are installed. Also, ISDN signaling software is required for ISDL to function.

MAX TNT Expansion Modules

IDSL module for MAX TNT and DSLTNT

The IDSL line card supports 32 ports per card and occupies one slot. The MAX TNT and DSLTNT may support up to 7 cards for a total of 224 IDSL ports. Each IDSL port supports a 128 Kbps digital connection to subscribers and connects end users' (third party) ISDN terminal adapters, Ascend's Pipeline and IP application software. ISDN signaling software is required to support IDSL. HDLC cards are not required since the HDLC controllers are built into the IDSL Card itself.

SDSL module for MAX TNT and DSLTNT

The SDSL line card supports 16 ports per card and occupies one slot. The MAX TNT and DSLTNT may support up to 15 cards for a total of 240 SDSL ports. Each SDSL port supports a 768 Kbps digital connection to subscribers' SDSL CPE equipment such as Ascend's DSLPipe-S (SDSL).

RADSL-CAP module for MAX TNT and DSLTNT

The Rate Adaptive RADSL (RADSL) adapts dynamically to the line condition and optimizes the transmission date rate. The RADSL-CAP line module supports six ports per card and occupies one slot. The MAX TNT and DSLTNT may support up to 15 cards for a total of 90 RADSL-CAP ports. Each RADSL-CAP port supports digital connection with speeds of 7 Mbps downstream and 1 Mbps upstream to subscribers' RADSL CPE equipment such as Ascend's DSLPipe-C (RADSL-CAP).

DS3 ATM Module for MAX TNT and DSL TNT

Ascend's MAX TNT/DSLTNT ATM Ds3 card provides direct access to ATM networks through both the MAX TNT WAN access switch and the DSLTNT Digital Subscriber Line concentrator. The high-density ATM DS3 card concentrates traffic from multiple lines and sends it directly to an ATM network, allowing carriers, CLECs and other service providers to offer end users faster access to more services without expensive hardware add-ons or lengthy software conversations.

RADSL-DMT module for MAX TNT and DSLTNT

The RADSL-CAP line card for the MAX TNT and DSLTNT provides a digital connection with speeds of 7 Mbps downstream and 1 Mbps upstream to subscribers' RADSL-DMT CPE equipment such as Ascend's DSLPipe-D (RADSL-DMT). The main difference between the RADSL-CAP and RADSL-DMT line cards is in the modulation technique used. Although the Discrete Multi-Tone (DMT) has been accepted as the standard (ANSI T1.413), the Carrier Amplitude Phase Modulation is more widely used by the carriers. Ascend's MAX TNT and DSLTNT provide a solution for both types of modulations.

Customer Premises Equipment (CPE)

Ascend's Pipeline products are offered as the CPE for the IDSL solution, and the DSLPipe products are offered as the CPE for other DSL technologies. These include the DSLPipe-S (SDSL), DSLPipe-C (RADSL-CAP) and DSLPipe-D (RADSL-DMT).

Pipeline ISDN Access Family

The Pipeline products are the ISDN-based CPE from Ascend. Since Ascend's IDSL solution is based on 2B1Q signaling, a standard used with ISDN BRI circuits, it will function with ISDN BRI terminal adapters from third party vendors as well as all the Pipeline Family.

DSLPipe-HS

The DSLPipe-HS is a SDSL-based CPE for connection to the network and it includes four ethernet ports. The speed of the connection to the CO can be up to 1.544 Mbps over a single twisted pair.

DSLPipe-2S

The DSLPipe-2S is a dual-line SDSL-based CPE for connection to the network, and it includes one Ethernet port. It also comes with a console port for connection to a VT-100 terminal for configuration of the unit. The speed of the

connections to the CO will be 768 Kbps each, for a total of 1.54 Mbps, which is a full T1 data rate using two lines. Frame Relay, PPP, MP, MP+ may be used on the SDSL line.

DSLPipe-S

The DSLPipe-S is a SDSL-based CPE for connection to the network, and it includes one Ethernet port. It also comes with a console port for connection to a VT-100 terminal for configuration of the unit. The speed of the connection to the CO will be 768 Kbps, which is half the T1 data rate using a single twisted pair. Although Frame Relay generally is used for data transmission, PPP can also be used if the DSL service-vice is offered by an ISP that requires PPP.

DSLPipe-C

The DSLPipe-C is an RADSL-CAP CPE that includes one connection to the CO and one Ethernet port. It also comes with a console port for connection to a VT-100 terminal for configuration of the unit. Depending upon the condition of the physical line, the speed of the connection to the CO may be as high as 7 Mbps downstream and 1 Mbps upstream over a single twisted pair. This unit utilizes the CAP modulation. Although Frame Relay generally is used for data transmission, PPP can also be used if the DSL service is offered by a service provider that requires PPP.

DSLPipe-D

The DSLPipe-D is an RADSL-DMT CPE that includes one connection to the CO and one Ethernet port. It also comes with a console port for connection to a VT-100 terminal for configuration of the unit. Depending upon the condition of the physical line, the speed of the connection to the CO may be as high as 7 Mbps downstream and 1 Mbps upstream over a single twisted pair. This unit utilizes the DMT modulation. Although Frame Relay generally is used for data transmission, PPP can also be used if the DSL service is offered by an ISP that requires PPP.

POTS Splitters

Splitters separate the POTS line from the DSL line. Generally they operate in pairs – one at the CO and the other at the customer premises. The CPE with DSL line and the analog telephone will be connected to the Splitter at the customer site. The Splitter at the CO splits the signal again and connects the POTS signal to the PSTN switch. Below is an accurate rendition of a typical POTS splitter application as it is frequently installed.

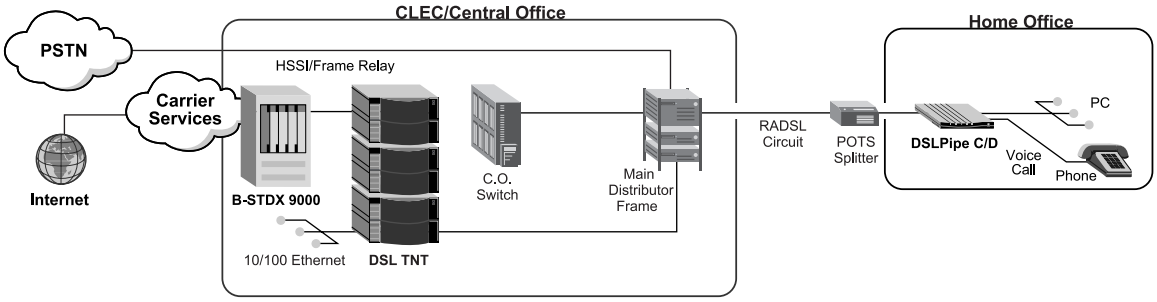

Figure 24 – Splitters for voice services are used at both the Central office and at the Customer site

7. Business/Cash Flow Analysis

The following analysis is assuming that the copper pair already exists between the users and the central location, that the copper is owned by the service provider and that end users provide their own CPE routers (DSLPipe products). Additionally it is assumed that Internet access is being provided by via either a partnership agreement with a competitive access provider or local ISP and that authentication services are provided as part of that access service. The pricing of DSL services is likely to vary widely depending upon specific market conditions in the geographic area of implementation – we have provided the range that we believe will be representative in the market during 1998 for DSL-based Internet access services.

Sample Service Provider Financial Model For IDSL Solution based on DSL TNT					
		Year 1	**Year 2**	**Year 3**	**Totals**
IDSL Access Ports Purchased	224				
Monthly Revenue per IDSL Access Port	$150				
Total Monthly Revenue	$33,600				
Annual Port Revenue		$403,200	$403,200	$403,200	$1,209,600
Total Revenue		$403,200	$403,200	$403,200	$1,209,600
Approx. Equipment Costs (per month per port lease)	$14.50				
Total Equipment Costs (per month per port/lease)		$38,976	$38,976	$38,976	$116,928
Estimated Installation/Maintenance Cost		$20,000	$20,000	$20,000	$60,000
Estimated WAN Costs (T3 Circuit)		$36,000	$36,000	$36,000	$108,000
Estimated Administration Costs		$40,000	$40,000	$40,000	$120,000
Total Costs		$134,976	$134,976	$134,976	$404,928
Net Profit/Loss		$268,224	$268,224	$268,224	$804,672
Margin		67%	67%	67%	67%
Sample Service Provider Financial Model for SDSL based on DSL TNT					
IDSL Access Ports Purchased	240				
Monthly Revenue per IDSL Access Port	500				
Total Monthly Revenue	$120,000				
Annual Port Revenue		$1,440,000	$1,440,000	$1,440,000	$4,320,000
Total Revenue		$1,440,000	$1,440,000	$1,440,000	$4,320,000
Approx. Equipment Costs (per month per port/ lease)	$20.00				
Total Equipment Costs (per month per port/lease)		$57,600	$57,600	$57,600	$172,800
Estimated Installation/Maintenance Cost		$20,000	$20,000	$20,000	$60,000
Estimated WAN Costs (T3 Circuit)		$36,000	$36,000	$36,000	$108,000
Estimated Administration Costs		$40,000	$40,000	$40,000	$120,000

Sample Service Provider Financial Model for SDSL based on DSL TNT (con't)					
Total Costs		$153,600	$153,600	$153,600	$460,800
Net Profit/Loss		$1,286,400	$1,286,400	$1,286,400	$3,859,200
Margin		89%	89%	89%	89%
Sample Service Provider Financial Model for IDSL based on the MAX 4004					
IDSL Access Ports Purchased	40				
Monthly Revenue per IDSL Access Port	$150				
Total Monthly Revenue	$6,000				
Annual Port Revenue		$72,000	$72,000	$72,000	$216,000
Total Revenue		$72,000	$72,000	$72,000	$216,000
Approx. Equipment (per month per port lease)	$14.50				
Total Equipment (per month per port/lease)		$6,960	$6,960	$6,960	$20,880
Estimated Installation/Maintenance Cost		$4,000	$4,000	$4,000	$12,000
Estimated WAN Costs (T3 Circuit)		$12,000	$12,000	$12,000	$36,000
Estimated Administration Costs		$5,000	$5,000	$5,000	$15,000
Total Costs		$27,960	$27,960	$27,960	$83,880
Net Profit/Loss		$44,040	$44,040	$44,040	$132,130
Margin		61%	61%	61%	61%

**The operating lease option availability is subject to a credit approval by Ascend Communications, Inc.*

For more information on leasing options please contact your local Ascend representative.

*Plus depreciation on TNT Concentrator – dependent upon your company's depreciation standard schedule.

Assumptions:

- Installation in a large shared-tenant building with full use of the 40, 224, or 240 DSL ports by subscribers
- Internet access services provided as part of a partnership between a building owner and service provider
- Internet Backbone Connectivity and Leased-line services to the DSL POP are already in place or provided by partner
- Backbone Routing Connectivity provided as part of Internet backbone connectivity
- Authentication is provided by the partnering service provider's RADIUS server

8. Line Monitoring and Test Equipment

It is important in any service business to be able to measure the quality of service and determine quickly if there are service problems. DSL services are no different in this respect and Ascend accordingly provides a range of software tools to help manage the network and quickly identify potential service problems. Ascend, as well as third party companies, provided the line monitoring, diagnostic and test tools that can help quickly identify and resolve potential quality of service problems.

Line Monitoring and Diagnostics

One of the key elements of a COE is the ability to test and verify the quality of the line from the CO. Ascend's MultiDSL line cards offer several loopback tests just for this purpose, as well as a number of other important measures to monitor your circuit quality. These tests include:

- **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 pin-point 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.

Third Party Suppliers of DSL Cable Testing Equipment

Traditional network diagnostic equipment providers are also now beginning to offer DSL line test equipment. One such product is the Fluke Corporation's xDSL OneTouch. Contact the local office of your telephone test equipment manufacturer for details.

Fluke Corporation

http://www.fluke.com

Corporate Headquarters

Tel: 1-425-347-6100

FAX: 1-425-356-5116

E-mail: fluke-info@tc.fluke.com

xDSL OneTouch™ makes it fast and easy to measure the performance and end-to-end connectivity of high-speed xDSL-based data service. Connected directly to the Ethernet interface of the modem, the xDSL OneTouch measures actual transmission rates and tests the entire xDSL connection – all the way back to the service provider's network – to ensure proper service delivery.

9. Why Partner with Ascend?

Ascend has a proven track record in helping network service providers succeed in their markets. Evidence of the MAX family's value is found in its adoption by over 80 of the world's 100 largest Internet service providers. In fact over 5000 ISP POPs worldwide utilize the MAX products, making Ascend the market leader by a wide margin.

When you partner with Ascend to provide DSL services you are leveraging the experience gained from over 6.0 million access ports installed, and worldwide market share leadership in analog and digital access concentrator sales.

Network service providers also benefit from the following list of unique corporate and product competitive advantages:

- Ascend is the only vendor to announce a fully integrated DSL product line strategy for both Central Office Equipment (COE) and Customer Premise Equipment (CPE) including IDSL, SDSL, HDSL, RADSL-CAP and RADSL-DMT.
- Ascend has the highest density DSL platform on the market today. The TNT supports up to 360 DSL circuits per chassis.
- Ascend is the only vendor to offer multiprotocol and multiservice (analog, ISDN and xDSL technologies) on a single integrated carrier-class WAN access switch such as the MAX TNT.
- Only Ascend MAX TNT supports the full array of analog and digital access technologies for maximum flexibility and expandability. MAX TNT allows a company to start by offering any of the standard DSL variants, and expand with analog, or switched or leased digital circuits at any time.
- Ascend has a strong track record of technical leadership in the Internet access and DSL fields: IDSL is a technological innovation from Ascend that leverages existing copper wires and CPE.
- Ascend technology supports a wide range of loopback tests to verify the integrity and quality of the local loop (between CO and residence/business locations).
- IDSL works with existing ISDN BRI Customer Premises Equipment such as terminal adapters and Pipeline products and existing IP application software.
- A wide range of protocols are supported, including Point-to-Point Protocol (PPP), MP, MP+ and Frame Relay.
- Ascend is one of the few vendors to offer a fully integrated security with stateful inspection-based firewall
- Customers may use any existing authentication and authorization security such as Ascend Access Control™, RADIUS, TACACS, TACACS+, Token-cards, PAP and CHAP.
- Support for the most detailed accounting information available in the industry facilitates billing by minutes or bytes/packets.
- Very affordable lease and purchase programs

Professional Services to help you succeed in the Service Provider business:

FastTrack – The FastTrack program consists of consulting and workshops as well as binder material to assist a service provider in defining and launching unique and competitive services. The program is a joint effort between Ascend and TeleChoice, Inc. TeleChoice is a leading telecommunications consulting firm which specializes in the marketing of broadband services.

The binders provide a how-to guide while the consulting and workshops provide customized consulting on these topics:

- Product Development
- Marketing and Marketing Communications
- Pricing
- Sales Training

Quickstart – The Quickstart program is a response to customer demand for support in the rapid deployment of a network. The Professional Services Group within Ascend Communications has packaged a set of services known as QuickStart services. These services range from support in defining the Service Provider's service to training the Service Provider's sales force. A key component of the QuickStart program is the Project Manager who coordinates all activities associated with the network deployment.

The QuickStart portfolio of services includes:

- Project Management
- Marketing Services Consulting
- Network Design and Engineering Services
- Network Operations Consulting
- Installation Services
- On-site Network Operations Support
- Custom Software Development and Consulting
- Training

Joint Marketing – Ascend works closely on joint marketing programs with partners that are implementing Ascend's DSL solutions.

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ASCEND

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