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DSL

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Introduction

The accelerated growth of content-rich applications that demand high bandwidth has changed the nature of information networks. High-speed communication is now an ordinary requirement throughout business, government, academic, and "work-at-home" environments. High-speed Internet access, telecommuting, and remote LAN access are three services that network access providers clearly must offer. These rapidly growing applications are placing a new level of demand on the telephone infrastructure, in particular, the local loop portion of the network (i.e., the local connection from the subscriber to the local central office). The local loop facility is provisioned with copper cabling, which cannot easily support high bandwidth transmission. This environment is now being stressed by the demand for increasingly higher bandwidth capacities. Although this infrastructure could be replaced by a massive rollout of fiber technologies, the cost to do so is prohibitive in today's business models. More importantly, the time to accomplish such a transition is unacceptable, because the market demand exists today!

This demand for data services has created a significant market opportunity for providers that are willing and able to invest in technologies that maximize the copper infrastructure. Both incumbent and competitive Local Exchange Carriers (ILECs and CLECs) are capitalizing on this opportunity by embracing such technologies.

The mass deployment of high-speed Digital Subscriber Line (DSL) has changed the playing field for service providers. DSL, which encompasses several different technologies, essentially allows the extension of megabit bandwidth capacities from the service provider central office to the customer premises. Utilizing existing copper cabling, DSL is available at very reasonable costs without the need for massive infrastructure replacement. These new DSL solutions satisfy the business need to provision the network in a fast, cost-effective manner, while both preserving the infrastructure and allowing a planned migration into newer technologies. DSL has the proven ability to meet the customer demand for high bandwidth right now, at costs that make sense.

ADSL, or Asymmetric DSL, has emerged as the technology of choice for delivering greater throughput to the desktop. Currently, the ADSL Lite specification, also known as g.lite, is expected to be standardized by the end of June, 1999 as a low-cost, easy-to-install version of ADSL specifically designed for the consumer marketplace. While g.lite is expected to become the predominant standard for consumer services, HDSL2 is becoming the protocol of choice for business services (more on HDSL2 to come).

The Telecommunications Infrastructure

The telecommunications industry has developed and deployed cost-effective technologies and created global, high-bandwidth, interoffice networks capable of supporting the demands of the information age. This network infrastructure, however, has been lacking one significant component—a ubiquitous low-cost, high-bandwidth access circuit for the local loop. This fact, more than any other, has slowed the growth and availability of high-bandwidth network services. The pervasive copper cable infrastructure deployed throughout the local loop was historically incapable of supporting the throughput required by growing consumer traffic. In response, the industry embraced DSL, which has proven to be the most significant technological development for solving the local loop demand for higher bandwidth.

Telephone Company Market Positioning

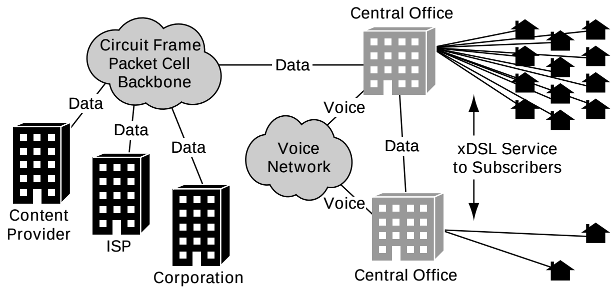
Telephone companies face CLECs, cable TV companies, and others in a head-to-head battle for market share. By offering new, advanced data services on their existing infrastructure of copper telephone lines, telephone companies are in an ideal position to capture new customers.

Telephone companies must provide aggressive new services that include voice, video, and high-speed data. These must be packaged, priced, and targeted for markets that have immediate needs and are willing to purchase them. This market opportunity has given rise to the integrated access concentrator, a solution that provides an economical, scaleable platform for the integration of voice, data, and video services. Integrated access concentrators enable telephone companies and other service providers to offer their customers extended services that are easy to deploy and profitable. The "end game" here is market share, product differentiation, and product mix. Achieving these results requires rapid deployment, unconstrained by bandwidth limits or deployment barriers.

Competitive Service Providers

As a result of regulatory changes, telephone companies are experiencing competition from several sources. CLECs are growing rapidly and looking for ways to offer higher bandwidth solutions to their customers. CLECs are in an ideal position to compete with other network service providers due to their data expertise, growing customer bases, and aggressive marketing tactics. Deregulation has given CLECs access to the copper wire, putting them in a position to offer DSL-based services.

Cable companies, serving a primarily residential base, are exploring new ways to deliver internet access to their customers over their existing coaxial cable plant. Competitive access providers, with existing fiber links from businesses to long distance carriers, are partnering with these carriers in offering direct competition for local exchange services.



Network Overview

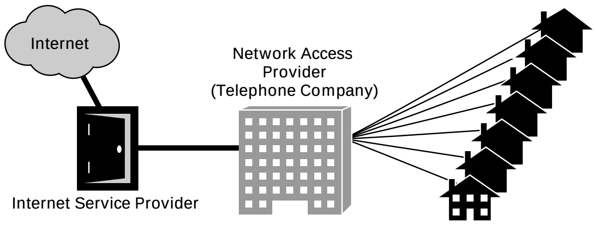
The Size of the Market for New Broadband Services

How important is it to expand local access bandwidth now? According to TeleChoice, of Verona, New Jersey, the combined potential revenue from new DSL services could exceed $695 million by the year 2000. The industry and the media have done a great job of setting consumer expectations for advanced data, video, and voice services. DSL technology enables the existing copper phone network to supply access to these services for rapid market entry and, ultimately, cost-effective universal access.

Along with technological advances, three business and cultural trends are driving the public's demand for higher bandwidth:

- High-Speed Internet Access
- Telecommuting
- Remote LAN Access

High-Speed Internet Access

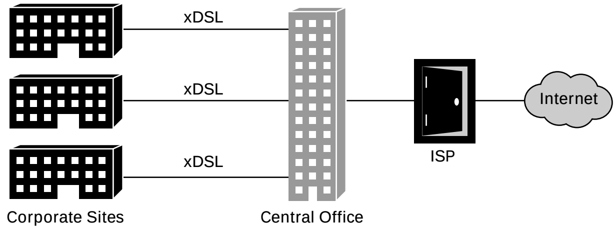


Consumer Application

Consumers

It is readily apparent to young teens, elder seniors, school teachers, and professionals in all fields, that the Internet is where it's happening! Commonly overheard conversations in all sorts of unexpected places are about 28.8 vs. ISDN, web sites, home pages, FTP, chat areas, URLs, e-mail, and more. This occurrence, totally unknown to the casual public just seven years ago, has come upon us with the same implacable certainty that pushed televisions into virtually every home in America over a period of ten years from 1950 to 1960. The taste for graphics, sound, live interaction, two-way video, and ubiquitous entertainment are already dissatisfied. Demands for better, quicker, richer and prettier are placing demands on the local telephone infrastructure as never before! The Internet is certain to be as pervasive as the telephone itself, and the demand for megabit rate bandwidth right to the desktop device is certain.

Network access providers targeting this category will be required to provide low-cost, easy-to-use, higher bandwidth solutions in a highly competitive arena. The new generation of Internet subscribers tends to be non-committed to any particular vendor and will easily change from one ISP to another, based on quality of service and cost. The key to quality of service is the fast reliable delivery of high bandwidth. These subscribers also need a relatively high degree of customer support. It represents a perfect opportunity to deploy ADSL technology on a subscriber by subscriber basis, as the demand warrants. ADSL, with it asymmetric bandwidth and stable technology, provides exactly the right mix for broad deployment of Internet services.



Business Application

Businesses

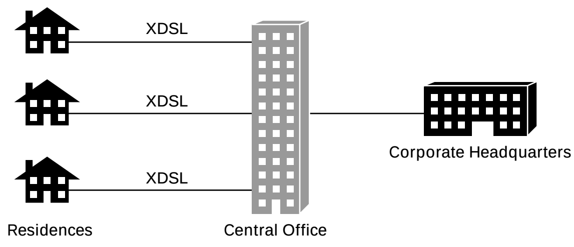
Businesses have had an equally intense preoccupation with the Internet. Businesses are currently formulating plans to use the Internet as an integral part of their networking strategies, with customer and vendor interactions, advanced web site developments, and more. On top of this is the move towards corporate-wide Intranets. Intranets are internally developed and deployed intra-company networks that operate in essentially the same way as the Internet itself. Major graphic-intensive applications, video, sound clips, large-scale database deployment, etc. are becoming mission critical for businesses as they develop revolutionary new business models.

Businesses are also implementing new applications, which, by their very nature, greatly expand the need for bandwidth capacity. These include collaborative processing applications, as well as desktop video conferencing, transmitting large graphic files, and real-time computing.

In addition to business Internet access, Virtual Private Networking (VPN) promises to change the way small and medium size businesses operate, by allowing them to pass data securely over the Internet. Over the next few years. most business locations in North America will use VPNs to create company-wide private networks, even for small remote branch offices or telecommuters. VPNs will drive the need for cost-effective bandwidth and help to proliferate the use of newer DSL technologies suitable for business applications, such as HDSL2.

Because these new Internet applications present such an exciting opportunity for all types of businesses, ISPs need to be able to provide highly reliable dedicated circuits in the T1 range. There is a greater need for two-way high bandwidth than in the consumer market. Businesses on the Internet anticipate high value and profitability for their investments. Service providers need to deliver security, quality, and cost efficiencies with a high degree of professional customer support to assist their clients in bringing new applications onto the network quickly. The best DSL solution for these customers is also HDSL2, because of its two-way bandwidth capacity and its operability on single pairs.

Telecommuting



Telecommuting Service

Work-at-home and remote office environments are becoming increasingly attractive to both employers and employees. Quality of life issues, a demand for more normalcy, and a lessening of the stress of today's frenzied existence are becoming important. Business models are based less on the tiered hierarchy of middle management and more on the deployment of workers based on functional areas, communities of interest, and core competencies. Management sees great value in restructuring the virtual workspace, unconstrained by the need for physical presence and multi-layered supervision. This leads to highly distributed work environments, some in individual homes, from which a worker “telecommutes” into core corporate resources. These work-at-home people are connected directly to the corporate network in a way that gives them a virtual presence. To make this happen, there is a need for suitable capabilities in terms of accessibility and bandwidth in the megabit range.

Workers in this environment, as opposed to those needing only Internet access, need high bandwidth in each direction. Whether working in collaborative activities using groupware software applications or moving images or other large files, these people require two-way high-bandwidth capacity in the megabit range. Simple Internet support is insufficient for this need. Furthermore, because of the mission-critical nature of many of these jobs, there is a great need for network reliability. This business model is valuable to employers, because of increased job efficiency and flexibility, as well as its potential for significant cost reductions. As a result, businesses are quite willing to pay the costs for these home services, since they will operate in a far more cost-efficient manner. In these situations, a number of DSL services will accommodate the user, with the choice depending on each “commuter’s” specific application.

Virtual Private Networks

As organizations continue to expand rapidly and globally, the demand for network services grows exponentially. Virtual Private Networks (VPNs) are becoming a favorable, cost-effective solution for organizations that wish to provide secure Internet access, file sharing, e-mail and video teleconferencing over WANs.

A VPN acts like a private network or LAN, except that a service provider manages the VPN. The service provider could be a CLEC, IXC or ISP. Organizations connecting more than three or four remote sites often consider the cost of purchasing more equipment, hiring skilled WAN expertise, and working with multiple vendors too expensive. By establishing a VPN, an organization can subscribe to value-added services, such as troubleshooting network problems and network security, from one location and minimize costs.

DSL is a particularly well-suited access method for organizations that use VPNs. CLECs, IXCs and ISPs commonly offer DSL, thus making access to bandwidth easier for organizations relying upon VPNs. Requiring only a LAN interface from each site to the service provider's network, VPNs can provide organizations with reliable access to bandwidth upstream and downstream without bottlenecks.

Application Bandwidth Requirements

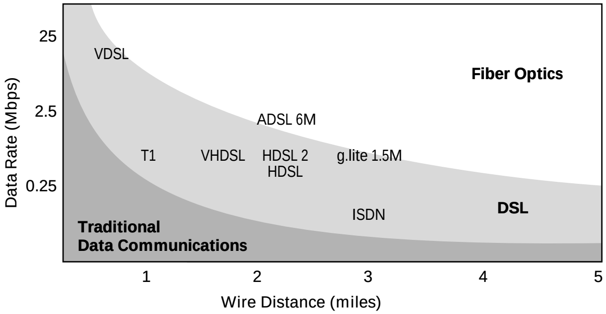
These various Internet access, telecommuting, and remote LAN access applications require significant bandwidth to meet their service level demands. File sizes of from 30 Kbytes to 30 Mbytes are commonplace and cannot be supported by traditional local loop bandwidth capacities. Corporations have several options involving the acquisition of traditional T1 (~1.5 Mbps) or T3 (~43 Mbps) lines, which are costly but possible for business access. However, when we include small work-at-home telecommuters or individual Internet users, this solution just doesn't work. Telephone company alternatives for these customers have thus far been limited to ISDN or analog voice grade circuits, which when equipped with 28.8 modems are minimally useful. The following chart shows the relative efficiency of these two possibilities compared to various DSL capabilities:

APPLICATION FILE TYPE	FILE SIZE	Modem 28.8 kbps	ISDN 128 kbps	xDSL 384 kbps	xDSL 768 kbps	xDSL 1544 kbps	xDSL 6144 kbps
All Users Email	30 Kbytes	8.3 sec.	1.9 sec.	0.63 sec.	0.31 sec.	0.16 sec.	0.04 sec.
Consumer Digitized Photo	125 Kbytes	34.7 sec.	7.8 sec.	2.6 sec.	1.3 sec.	0.6 sec.	0.2 sec.
Business User Word Files	250 Kbytes	69.4 sec.	15.6 sec.	5.2 sec.	2.6 sec.	1.3 sec.	0.3 sec.
Telecommuter Videoconferencing	384 kbps	No	No	Yes	Yes	Yes	Yes
Telemedicine X-ray	5 Mbytes	23.1 min.	5.2 min.	1.7 min.	52.1 sec.	25.9 sec.	6.5 sec.
Remote LAN Access Bulk File	20 Mbytes	1.5 hr.	20.0 min.	6.9 min.	3.5 min.	1.7 min	26.0 sec.

Desired and acceptable response time is less than 3.0 seconds

DSL Solutions

DSL refers to a set of similar technologies that provide high bandwidth over copper twisted pair local loop cable, without amplifiers or repeaters along the cable route. It refers to the connection between the customer and the first node within the network. DSL is provided over non-loaded local copper loops[1] that are the overwhelming majority of cable facilities in a telephone exchange area.



DSL Reaches & Rates

DSL technology is compatible with existing services, such as POTS (plain old telephone service), ISDN, and DDS, and will work over the majority of copper loops existing today.

1 "Loading" in telephony parlance refers to the addition of small coils, or inductors, in series with the loop at regular intervals. This technique is used to "flatten" the frequency response of the cable transmission line over the voice band, much like an equalizer in a stereo system. 2 CAP is a derivative of Quadrate Amplitude/Phase Modulation (QAM) which has been widely used in modems for over 20 years. DSL transceivers use an integrated 2-Dimensional 8-State Trellis coding) with Viterbi decoding and Reed-Solomon forward error correction to provide reliable transmission in the presence of line impairments. Adaptive channel equalization is also employed to ensure performance against channel impairments and narrowband interference.

DSL Supports Industry Standards

DSL technology supports industry-standard transmission formats and bit rates, such as T1 (1.544 Mbps) and E1 (2.048 Mbps), and is sufficiently flexible to support additional rates and formats as they are defined (e.g., 6 Mbps asymmetric for high-speed data and video). DSL technology coexists in the loop with voice. As a result, all types of services, including the existing voice, video, multimedia, and data services can be carried without developing new payload strategies or standards from scratch. This is critical to seamless deployment of higher bandwidth-based services.

Modem Like Technology

DSL is a modem-like technology in that it requires a DSL terminating device at each end of the cable pair, which accepts a data stream, usually in digital format, and overlays it onto a high-speed analog signal. ADSL, g.lite, VDSL and RADSL are designed to coexist with POTS on the same twisted pair.

Symmetric and Asymmetric

DSL technology provides symmetric and asymmetric bandwidth configurations to support both one way and two way high bandwidth requirements. We refer to configurations as symmetric if the channel bandwidth needed or provided is the same in both directions. Traditional POTS (plain old telephone service), for example, is a symmetric application (albeit, relatively low-bandwidth in nature).

The Flavors of DSL

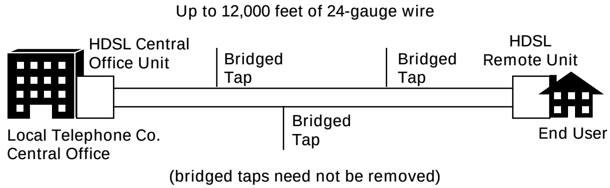
There are various flavors of DSL technologies, all with their respective acronyms: High-bit-rate Digital Subscriber Line (HDSL), the second generation of HDSL (HDSL2), Single-pair High-bit-rate Digital Subscriber Line (S-HDSL), Symmetric Digital Subscriber Line (SDSL), Asymmetric Digital Subscriber Line (ADSL), Rate Adaptive Digital Subscriber Line (RADSL) and Very High-bit-rate Digital Subscriber Line (VDSL). These terms refer to the way transmission bandwidth is configured and used to support the customer's bandwidth needs.

DSL

Digital Subscriber Line is fundamentally another name for an ISDN-BRI channel operating at the Basic Rate Interface with two 64 Kbps circuit switched channels and one 16 Kbps packet switching and signaling channel. This circuit can carry both voice and data in both directions at the same time.

However, DSL has come to refer to those various arrangements in which advanced modulating techniques are imposed onto the local channel in order to derive higher throughput in one or both directions. The various types of DSL are described in the following sections.

HDSL



HDSL Circuit

High-bit-rate Digital Subscriber Line (HDSL) derives its name from the high bandwidth that is transmitted in both directions over two copper loops. HDSL has proven to be a reliable and cost effective means for providing repeater-less T1 and E1 services over two twisted pair loops. This proven technology has already resulted in the deployment of over 1.5 million HDSL equipped circuits throughout the local access infrastructure. HDSL transceivers can reliably transmit a 2.048 Mbps data signal over two non-loaded, 24 gauge (0.5mm), unconditioned twisted wire pair loops at a distance of up to 13 kft (4.2 km) without the need for repeaters.

Eliminating the need for repeater equipment and removal of bridged taps significantly simplifies the labor and engineering effort to provision the service. This attribute eliminates the need to identify, modify, and verify a controlled environment, with power, secured access, and other factors needed to support repeater equipment. It also reduces the time, cost, and effort of isolating faults and taking corrective action when a failure does occur. Studies by some service providers have indicated that trouble shooting and replacing defective repeater equipment often costs significantly more than the cost of the equipment itself. These attributes translate into increased network up time and reduced engineering time; making possible T1 provisioning in a matter of days, as opposed to weeks. Faster service provisioning and greater up time leads to increased customer satisfaction and increased service revenues. To provision a 12 kft (3.6 km) local loop with traditional T1 transmission equipment requires two transceivers and two repeaters. To provision the same loop with HDSL requires only two HDSL transceivers, one at each end of a line.

HDSL2

HDSL2 is the next generation of HDSL. HDSL2 was designed to accomplish three primary goals. The first being full T1 rates (1.544 Mb/s) on a single pair of copper with the same spectral compatability as traditional HDSL, the second being vendor interoperability, meaning that service providers are no longer tied to proprietary solutions (both line line and remote-end transceiver units can be mixed and matched among vendors) and the third being that it must extend to full CSA reach which is 12,000 feet.

HDSL2 can be thought of as offering everything traditional HDSL offers, but it can be done on a single pair of copper.

HDSL2 is unique in the fact that it is a standardized technology, unlike other single-pair solutions, such as SDSL. It is important to remember that all products are intended to be interoperable. But in order to be an interoperable product, among many criterion defined by the HDSL2 standard, all products must use the HDSL2 OPTIS line code which was invented by PairGain Technologies (one of the many contributors to the ANSI standards committee). Vendors that adhere to the standard by using OPTIS will all be interoperable. Unfortunately there are currently some vendors claiming to have HDSL2, but they are not using OPTIS or an OPTIS chip-set. This is a false claim and unfortunately their products will not be interoperable as they are not compliant with the HDSL2 standard.

HDSL2 is a technology that offers great benefits to all service providers because it allows them to deliver twice the bandwidth on the same number of pairs that they currently use to deliver traditional HDSL. In some cases it will allow providers an opportunity to drop a noisy pair while still providing service to the same number of customers. Also, with HDSL2 being an interoperable solution, it opens up the marketplace, which favors service providers. No longer are they tied to a proprietary solution. An interoperable product means that not only can RBOCS and CLECS buy from multiple vendors, but their vendors will be competing for business with a near- commodity product. This means that the service providers will see better pricing, enhanced features and outstanding customer service, as the suppliers strive to differentiate themselves.

S-HDSL/SDSL

S-HDSL/SDSL operate on a single copper pair as opposed to the traditional two-pair HDSL described above. S-HDSL/SDSL allows easy implementation of applications that require symmetric data rates on a single local loop while maintaining the existing POTS on the same loop. Because only one pair is needed in this arrangement, the capacity of the entire local loop infrastructure is greatly magnified. With this capability, local providers can extract the maximum value from their existing plant, or deploy new capacities both more quickly and at a lower capital expenditure.

This allows for rapid and cost effective deployment of intermediate data rate services. Potential uses for this technology include fractional T1 with a particular advantage in 768 Kbps systems, Work-at-home LAN Access, Distance Learning, Internet Access, and Campus or Large Facility LAN to LAN connectivity. Since S-HDSL/SDSL can be implemented with and without POTS and at multiple data rates, it can have different capacity and reach limitations.

This also allows for easy, cost-effective implementation of such services as remote cell site support of PCs, remote LAN access, distance education and training, digital imaging, or any other service, which requires a larger amount of bandwidth.

ADSL

Asymmetric Digital Subscriber Line takes its name from the comparatively high bandwidth in one direction, with low bandwidth in the opposite direction. ADSL uses a single phone line for transmission. Many service providers have also come to recognize its potential to support a range of data applications.

Additionally, ADSL's ability to operate at speeds of up to 8 Mbps positions it to support real-time broadcast services and pre-recorded interactive video services; and to have multiple video and data activities underway simultaneously. ADSL supports applications with asymmetric traffic demands such as:

- Web Surfing
- File Downloads
- Distance Learning

ADSL Lite or g.lite

ADSL Lite is a sub-rated ADSL solution, with reduced digital signal processing requirements than full-rate ADSL systems. Under the name of g.lite, the ADSL Lite specification is in final review by the ITU for standardization. ADSL Lite has a downstream data rate of 1.5 Mbps or less. It has a similar reach to full-rate ADSL systems. ADSL Lite is seen as the key to mass deployment of ADSL services, because the adaptation of this technology into high-speed modems is ideal for consumer use.

RADSL

Rate Adaptive Digital Subscriber Line (RADSL) is a simple extension of ADSL used to encompass and support a wide variety of data rates depending on the line's transmission characteristics. This is advantageous in situations where the line is no longer or has a lower quality, and a lower data rate is acceptable.

VDSL

Very High-bit-rate Digital Subscriber Line (VDSL) provides very high bandwidth asymmetrically (up to 52 Mbps in one direction and 2 Mbps in the other) to businesses and residences with broadband access requirements over a Fiber-To-The-Curb (FTTC) network. Within the FTTC architecture, VDSL will address the last section of copper cabling to the subscriber premises. Typical distance and implementation of VDSL is 1 km @ 26 Mbps.

DSL Technology

There are three different modulating techniques presently in use to support DSL. These are 2B1Q, Discrete Multi-tone modulation (DMT), and Carrierless Amplitude Phase modulation (CAP).

2B1Q

2B1Q represents a straightforward signal type that has two bits per baud arranged as one quaternary or four-level pulse amplitude modulated scheme. It essentially transmits data at twice the frequency of the signal.

Discrete Multi-tone modulation (DMT)

DMT is a newer, multi-carrier, technology that divides the three channels into 256 sub-channels onto which traffic is overlaid. This essentially adds a layer of multiplexing to the data stream. It has the benefit of being able to distinguish and isolate sub-channels with inferior quality or too much interference and assign traffic to neighboring sub-channels instead. This provides a robust approach resulting in high quality and reliability.

Carrierless Amplitude/Phase modulation (CAP)

Carrierless Amplitude/Phase modulation (CAP) is a proprietary digital modulation technique [2]. It is relatively low in cost and is based on a mature technology. CAP ADSL, for example, offers 7.5 Mbps downstream with only 1 Mbps upstream, while DMT-based ADSL offers 8 Mbps downstream and up to 1 Mbps upstream. DMT, in addition, is the official ANSI, ETSI and ITU-T standard for ADSL.

One twisted copper wire pair supports POTS in the 0-4 kHz bandwidth. CAP-based DSL technology uses frequencies sufficiently above the POTS “voice band” to provide bandwidth for low-speed upstream and high-speed downstream channels.

2. CAP is a derivative of Quadrature Amplitude/Phase Modulation (QAM) which has been widely used in modems for over 20 years. DSL transceivers use an integrated 2-Dimensional 8-State Trellis coding with Viterbi decoding and Reed-Solomon forward error correction to provide reliable transmission in the presence of line impairments. Adaptive channel equalization is also employed to ensure performance against channel impairments and narrowband interference.

Summary

Considering the need to support the growing demand for Internet access combined with telecommuting and LAN interconnectivity, we see that DSL offers the carrier community, Internet service provider, and competitive access provider, an amazingly serendipitous opportunity. Faced with the challenge of deploying solutions that meet the growing needs of an expanding market, service providers are quickly coming to the conclusion that DSL presents them with a remarkably valuable set of options. Because DSL technologies have matured so quickly and have established a secure, dependable, and broad penetration into the industry, high bandwidth applications can now be supported in a cost effective and competitive basis.

Internet access, telecommuting, and LAN access can be supported as never before. DSL, being compatible with ISDN and traditional standards such as T1, can be used to deploy those capabilities as well. Given these important and far reaching developments, it is clear that DSL technologies will be a major component of future service provider infrastructure plans. Using these capabilities, providers can offer a full range of cost effective services, deploy them quickly, and be assured of superb service. DSL solutions also offer service providers the ability to maximize personnel resources, using existing skills and employees with great efficiency. Consequently, their customers will have a high level of satisfaction and the providers can potentially experience a healthy profit on their investments.

Glossary

10BASE-T—The Institute of Electrical and Electronic Engineers (IEEE) 802.3 specification for Ethernet over thin coaxial cable.

2B1Q—2 binary, one quaternary. A one-dimensional modulation for transmitting 2 bits per symbol. 2B1Q is a 4-level PAM (pulse amplitude modulation) system used for HDSL/SDSL, S-HDSL, and ISDN BRI.

Access Provider—Organization providing and maintaining network services for subscribers.

Asymmetric Digital Subscriber Line (ADSL)—A new method of transmitting at speeds up to 7.5 Mbps in one direction over a single copper telephone line, and up to 1 Mbps in the other direction.

ADSL Lite (g.lite)—A subrated ADSL system, with a data rate limited to 1.5 Mbps or less downstream 500 kbps upstream. It is in its final stages of review by ITU committee for adoption as the standard known as g.lite. ADSL Lite systems offer lower data throughput, and reduced digital signal processing requirements than full-rate ADSL systems.

ANSI T1.403—The performance monitoring, data link, and network interface requirements for ESF CSUs as defined by the Exchange Carriers Standards Association. T1.403 specifies automatic performance reports transmitted to the network once per second via the data link. (In an E1 environment, Performance Monitor is the equivalent of T1.403).

ANSI T1.413—The interface standard for DMT ADSL.

Asymmetric Transmission—Transmissions that send data at different rates in each direction, faster downstream than upstream in most cases.

Asynchronous Transfer Mode (ATM)—The key emerging technology that uses fixed-length packets or cells to switch voice, data and video traffic over the local- and wide-area network.

B Channel—In ISDN, a full duplex, 64 kbps channel for sending data.

Backbone networks—The main artery or link for a private or public network. Typically the backbone carries the lion's share of traffic (data, voice, video or some combination), is capable of carrying significant bandwidth and it is the network to which small/remote networks/links are attached.

Bandwidth—A term now used to describe the capacity or amount of traffic (data, voice or video) a certain communications line is capable of accommodating.

Basic Rate Interface (BRI)—Reference ISDN.

Bit Error Rate (BER)—The ratio of received bits that are in error.

Bits Per Second (bps)—The number of bits passing a point every second. The transmission rate for digital information.

Bridge/Router—A device that can provide the functions of a bridge, router or both concurrently. Bridge/router can route one or more protocols, such as TCP/IP and/or XNS, and bridge all other traffic.

Broadband—Data transmission at a high rate, generally greater than T1 speeds (1.5 Mbps). This allows the transmission of voice, data and video signals over a single medium.

Cable modem—Modem designed for use on TV coaxial cable circuit.

Campus Area Network—A network that encompasses interconnectivity between floors of a building and/or buildings in a confined geographic area such as a campus or industrial park. Such networks would not require public rights-of-way and operate over fairly short distances.

CAP—Carrierless Amplitude/Phase Modulation. A two-dimensional line code used in ADSL.

Central Office—A local telephone company office which connects to the main system where circuit switching of customer lines occurs.

Channel—A communication path. Multiple channels can be multiplexed over a single cable in certain environments. The term is also used to describe the specific path between large computers and attached peripherals.

Channel Service Unit/Data Service Unit (CSU/DSU)—A digital interface unit that connects end user equipment to the local digital telephone loop.

Circuit-Switched Network—Network that establishes a physical circuit temporarily, until it receives a disconnect signal.

Competitive Access Provider (CAP) or Competitive Local Exchange Carrier (CLEC)—Alternative provider to Local Exchange Carrier (LEC).

Circuit Switching—Switching system in which a dedicated physical circuit path must exist between sender and receiver for the duration of the “call”. Used heavily in the phone company network, circuit switching often is contrasted with contention and token passing as a channel-access method, and with message switching and packet switching as a switching technique.

Coder/Decoder (Codec)—Equipment to convert between analog and digital information format. Also may provide digital information format. Also, may provide digital compression functions.

CLEC—Competitive Local Exchange Carrier.

Concentrator—Device that serves as a wiring hub in star-topology network. Sometimes refers to a device containing multiple modules of network equipment.

Crosstalk—Line static that can occur when wire pairs within the same bundles are used for separate signal transmission. Especially evident with repeatered T1/E1 transmission.

Customer Premises Equipment (CPE)—Terminating equipment, such as terminals, phones, routers and modems, supplied by the phone company, installed at customer sites, and connected to the phone company network.

D Channel—Full duplex 16 kbps (basic rate) or 64 kbps (primary rate) ISDN channel.

Dedicated Line—A transmission circuit installed between two sites of a private network and “open,” or available, at all times.

Dial up—A type of communication that is established by a switched-circuit connection using the public telephone network.

DDS (Data phone Digital Services)—DDS has come to refer either to the digital data service transport method, or to the brand name of the AT&T service it introduced in the early 1970s. Prior to T1, DDS facilitates were the fastest digital systems.

Digital Signal 0 (DS-0)—(1) North American Digital Hierarchy signaling standard for transmission at 64 kbps. (2) Digital Signal Level 0 is the worldwide standard transmission rate (64 kbps) for PCM digitized voice channels. 24 DS-0s exist in each DS1 (T1) signal.

Digital Signal 1 (DS-1)—North American Digital Hierarchy signaling standard for transmission sat 2.544 Mbps. Supports 24 simultaneous DS-0 signals. Term often used interchangeably with T-1, although DS-1 signals may be exchanged over other transmission systems.

Digital Subscriber Line (DSL)—Another name for an ISDN BRI channel. Operated at the Basic Rate Interface (with two 64 kbps circuit switched channels and one 16 kbps packet switched channel), the DSL can carry both voice and data signal at the same time, in both directions, as well as the signaling data used for call information and customer data.

Digital Signal Processing (DSP)—The processing of signal transmission using digital techniques.

DMT—Discrete Multi-tone. In DMT, a large number of low-rate carrier frequencies are QAM-modulated at a low rate to transmit a single high-rate data stream. DMT is used for ADSL and proposed for VDSL.

Echo Cancellation—Process by which a transmitter/receiver cancels out the transmitted signal as to "hear" the received signal better.

E1—The term for a digital facility used for transmitting data over a telephone network at 2.048 Mbps. The European equivalent of T1.

E3—The highest transmission rate generally available in the European digital infrastructure (34 Mbps).

Enterprise Network—A large typical corporate network under the auspices of one organization.

Ethernet—A baseband LAN specification invented by Xerox Corporation and developed jointly by Xerox, Intel, and Digital Equipment Corporation. Ethernet networks operate at 10 Mbps using CSMA/CD to run over coaxial cable. Ethernet has become a series of standards produced by IEEE referred to as IEEE 802.3.

Fiber Optics—A method for the transmission of information (sound, pictures, data). Light is modulated and transmitted over high purity, hair-thin fibers of glass. The bandwidth capacity of fiber optic cable is much greater than that of conventional cable or copper wire.

Fiber Optic Cable—A transmission medium that uses glass or plastic fibers, rather than copper wire, to transport data or voice signals. The signal is imposed on the fiber via pulses (modulation) of light from a laser or a light-emitting diode (LED). Because of its high bandwidth and lack of susceptibility to interference, fiber-optic cable is used in long haul or noisy applications.

Fractional T1—A WAN communications service that provides the user with some portion of a T1 circuit that has been divided into 24 separate 64 kbps channels.

Frame Relay—A streamlined packet switching protocol designed to provide high-speed frame or packet switching with minimal delay and efficient bandwidth usage.

Gigabits Per Second (Gbps)—1,000,000,000 bits per second. A measure of transmission speed. Any speed above gigabits would be referred to as terabits.

Headend—The source end of a coaxial cable TV system. Often, the site for signal processing equipment essential to proper functioning of a cable system.

High-bit-rate Digital Subscriber Line (HDSL)—Designed to be a cost-effective method of delivering T1/E1 line speeds over two pair of unconditioned copper cable, without the use of repeaters.

HDSL2—The next generation of HDSL, requiring only a single twisted copper pair to transmit at the same data rate and distance of regular HDSL over two-pair. When configured over two pairs, HDSL2 provides extended reach or greater throughput.

Institute of Electrical and Electronic Engineers (IEEE)—Professional organization that defines network standards. IEEE LAN standards are the predominant LAN standards today, including protocols similar or virtually equivalent to Ethernet and Token Ring.

Integrated Access Concentrator—The new breed of telecommunication platforms that combines multiple technologies in order to support voice, data, and video transmission from a single edge switch.

Integrated Services Digital Network (ISDN)—An ITU-T networking standard devised to provide end-to-end, simultaneous handling of digitized voice and data traffic on the same link.

Interexchange Carrier (IXC)—A long-distance telephone company offering circuit-switched, leased-line or packet-switched service or some combination.

Interface—(1) The point at which two systems or pieces of equipment are connected. (2) A connection between two systems or devices. A shared boundary defined by common physical interconnection characteristics, signal characteristics, and meanings of interchanged signals.

ISP—Internet Service Provider

Intranet—A private network that uses Internet software and standards.

ITU-T—International Telecommunication Union

Kilobits per second (kbps)—1,000 bits per second. A measure of transmission speed.

Last mile—A reference to the local loop, the distance between a local telco office and the subscriber, a distance actually about 0 to 3 miles (0 to 4 kilometers).

Leased Line—A transmission line reserved by a communications carrier for the private use of a customer.

Lifeline POTS—A minimal telephone service designed to extend a "lifeline" to the telephone system in case of emergency, particularly when electric power is lost.

Line code—Any method of converting digital information to analog form for transmission on a telephone line. 2B1Q, DMT, and CAP are all line codes.

Link—Physical connection between two nodes in a network. It can consist of a data communication circuit or a direct channel connection.

Local Area Network (LAN)—The means by which a local community of users and workgroups can share information and resources electronically. Many communications protocols are used to accomplish this, the most prevalent of which are Ethernet and Token Ring.

Local Area Transport Area (LATA)—(1) A geographic area established for the provision and administration of communications service. It encompasses one or more designated exchanges, which are grouped to serve common social, economic and other purposes. (2) Contiguous local exchange areas that include every point served by a LEC within an existing community of interest and that serve as the dividing line for the allocation of assets and liabilities between the IXC and the LEC. (3) A telephone company term that defines a geographic area; sometimes corresponds to an area code.

Local Loop—Refers to the physical copper pair or loop of wire from Central Office to the subscriber.

Metropolitan Area Network (MAN)—A data communication network covering the geographic area of a city. Often used by a competitive access providers to carry backbone traffic in their serving area.

Modulation—Process by which signal characteristics are transformed to represent information. Types of modulation include frequency modulation (FM), where signals of different frequencies represent different data values.

Multiplexer (MUX)—(1) A technique that enables several data streams to be sent over a single physical line. It is also a function by which one connection from a layer is used to support more than one connection to the next higher layer. (2) A device for combining several channels to be carried by one line or fiber.

Network Interface Card (NIC)—The circuit board installed in a PC that provides the interface between a communicating PC and the network.

Network Management System (NMS)—A system responsible for managing at least part of a network. NMSs communicate with agents to help keep track of network statistics and resources.

Open Systems Interconnection (OSI)—A 7-layer architecture model for communications systems developed by ISO and used as a reference model for most network architectures.

OPTIS—The ANSI standard line code for HDSL2. OPTIS stands for Overlapped PAM transmission with interlocking spectra and employes unique spectral shaping to meet the performance and capatibility goals of HDSL2.

Packet—(1) A logical grouping of information that includes a header and (usually) user data. (2) Continuous sequence of binary digits of information is switched through the network and an integral unit.

Packet Switched Network—A network in which data is transmitted in units called packets. The packets can be routed individually over the best available network connection and reassembled to form a complete message at the destination.

Pair gain—The multiplexing of x phone conversations over a lesser number of physical capacities. “Pair gain” is the number of conversations obtained, divided by the number of wire pairs used by the system.

Permanent Virtual Circuit (PVC)—A defined virtual link with fixed end-points that are set-up by the network manager. A single virtual path may support multiple PVCs.

POTS—Plain old telephone service.

Postal, Telegraph and Telephone Company (PTT)—Generic term for a provider of these services. A governmental agency in many countries.

QAM—Quadrate Amplified Modulation. A two-dimensional modulation used for ADSL, cable modems and proposed for VDSL. CAP is a special case of QAM. In QAM, a single carrier frequency is modulated in both sine and cosine components.

RADSL—Rate-Adaptive ADSL. A simple extension of ADSL to encompass a wide variety of data rates depending on the line's transmission capability. RADSL can be either CAP or DMT ADSL.

Regional Bell Operating Companies (RBOC)—Seven LEC telephone companies created after AT&T divestiture.

Remote LAN Access—A data communications such as a corporate or campus environment in which the computer networks can be accessed remotely via public telecommunications networks.

Repeater—An electronic device used to regenerate digital signals and restore signal quality across a certain distance of cable.

SDSL—Symmetric Digital Subscriber Line.

S-HDSL—Single pair transmission using HDSL technology, normally 2B1Q.

Simple Network Management Protocol (SNMP)—A network management standard initially established to allow multi-vendor network devices to be managed more easily with common management tools.

Switched Virtual Circuit (SVC)—A virtual link, with variable end-points, established through an ATM network. With an SVC, the user defines the end-points when the call is initiated that are subsequently terminated at the end of the call. With a Permanent Virtual Circuit (PVC), the network manager predefines the end-points. A single virtual path may support multiple SVCs.

Symmetric Transmission—Transmission in which a channel sends and receives data with the same signaling rate.

Synchronous Optical Network (SONET)—A recently emerging networking standard that utilizes fiber optics to create backbone networks, capable of transmitting at extremely high speeds and accommodating gigabit-level bandwidth.

T1—Digital transmission facility operating with a nominal bandwidth of 1.544 Mbps. Also known as Digital Signal Level 1 (D1). Composed of 24 DS-0 channels in many cases. The T1 digital transmission system is the primary digital communication system in North America.

T3—Digital transmission facility operating at 45 Mbps bandwidth. Composed of 28 DS-1 channels in many cases. Also known as DS-3.

Telecommuter—Person who performs work at home while linked to the office by means of a telecommunications-equipped computer system.

Transmission Control Protocol/Internet Protocol (TCP/IP)—A reliable, full duplex, connection-oriented end to end transport protocol running on top of IP.

Transparent LAN Service—Service offered by a provider that is used to connect LANs at geographically separated sites. “Transparent” means the connection is invisible to the user and typically runs at the same speed as the LAN.

Twisted Pair—Cable consisting of two 26 AWG (American Wire Gauge) solid copper strands twisted around each other. The twisting provides a measure of protection from electromagnetic and radio-frequency interference.

VLSI—Very Large Scale Integration.

VOD—Video On Demand

VPN—Virtual Private Network

Wide Area Network (WAN)—A network which encompasses interconnectivity between devices over a wide geographic area.

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