

TECHNOLOGY PAPER ON DIGITAL SUBSCRIBER LINE

DSL (Digital Subscriber Line) is a technology for bringing high-bandwidth information to homes and small businesses over ordinary copper telephone lines. xDSL refers to different variations of DSL, such as ADSL, HDSL, and RADSL. Assuming your home or small business is close enough to a telephone company central office that offers DSL service, you may be able to receive data at rates up to 6.1 megabits (millions of bits) per second (of a theoretical 8.448 megabits per second), enabling continuous transmission of motion video, audio, and even 3-D effects. More typically, individual connections will provide from 1.544 Mbps to 512 Kbps downstream and about 128 Kbps upstream. A DSL line can carry both data and voice signals and the data part of the line is continuously connected. DSL installations began in 1998 and will continue at a greatly increased pace through the next decade in a number of communities in the U.S. and elsewhere. Compaq, Intel, and Microsoft working with telephone companies have developed a standard and easier-to-install form of ADSL called G.Lite that is accelerating deployment. DSL is expected to replace ISDN in many areas and to compete with the cable modem in bringing multimedia and 3-D to homes and small businesses.

How It Functions

Traditional phone service (sometimes called "Plain Old Telephone Service" or POTS) connects your home or small business to a telephone company office over copper wires that are wound around each other and called twisted pair. Traditional phone service was created to let you exchange voice information with other phone users and the type of signal used for this kind of transmission is called an analog signal. An input device such as a phone set takes an acoustic signal (which is a natural analog signal) and converts it into an electrical equivalent in terms of volume (signal amplitude) and pitch (frequency of wave change). Since the telephone company's signalling is already set up for this analog wave transmission, it's easier for it to use that as the way to get information back and forth between your telephone and the telephone company. That's why your computer has to have a modem – so that it can demodulate the analog signal and turn its values into the string of 0 and 1 values that is called digital information.

Because analog transmission only uses a small portion of the available amount of information that could be transmitted over copper wires, the maximum amount of data that you can receive using ordinary modems is about 56 Kbps (thousands of bits per second). (With ISDN, which one might think of as a limited precursor to DSL, you can receive up to 128 Kbps.) The ability of your computer to receive information is constrained by the fact that the telephone company filters information that arrives as digital data, puts it into analog form for your telephone line, and requires your modem to change it back into digital. In other words, the analog transmission between your home or business and the phone company is a bandwidth bottleneck.

Digital Subscriber Line is a technology that assumes digital data does not require change into analog form and back. Digital data is transmitted to your computer directly as digital data and this allows the phone company to use a much wider bandwidth for transmitting it to you. Meanwhile, if you choose, the signal can be separated so that some of the bandwidth is used to transmit an analog signal so that you can use your telephone and computer on the same line and at the same time.

Splitter-based vs. Splitterless DSL

Most DSL technologies require that a signal splitter be installed at a home or business, requiring the expense of a phone company visit and installation. However, it is possible to

manage the splitting remotely from the central office. This is known as splitterless DSL, "DSL Lite," G.Lite, or Universal ADSL and has recently been made a standard.

Modulation Technologies

Several modulation technologies are used by various kinds of DSL, although these are being standardized by the International Telecommunication Union (ITU). Factors affecting the Experienced Data Rate DSL modems follow the data rate multiples established by North American and European standards. In general, the maximum range for DSL without a repeater is 5.5 km (18,000 feet). As distance decreases toward the telephone company office, the data rate increases. Another factor is the gauge of the copper wire. The heavier 24 gauge wire carries the same data rate farther than 26 gauge wire. If you live beyond the 5.5 kilometer range, you may still be able to have DSL if your phone company has extended the local loop with optical fiber cable.

The Digital Subscriber Line Access Multiplexer (DSLAM)

To interconnect multiple DSL users to a high-speed backbone network, the telephone company uses a Digital Subscriber Line Access Multiplexer (DSLAM). Typically, the DSLAM connects to an asynchronous transfer mode (ATM) network that can aggregate data transmission at gigabit data rates. At the other end of each transmission, a DSLAM demultiplexes the signals and forwards them to appropriate individual DSL connections.

Types of DSL

ADSL

The variation called ADSL (Asymmetric Digital Subscriber Line) is the form of DSL that will become most familiar to home and small business users. ADSL is called "asymmetric" because most of its two-way or duplex bandwidth is devoted to the downstream direction, sending data to the user. Only a small portion of bandwidth is available for upstream or user-interaction messages. However, most Internet and especially graphics- or multi-media intensive Web data need lots of downstream bandwidth, but user requests and responses are small and require little upstream bandwidth. Using ADSL, up to 6.1 megabits per second of data can be sent downstream and up to 640 Kbps upstream. The high downstream bandwidth means that your telephone line will be able to bring motion video, audio, and 3-D images to your computer or hooked-in TV set. In addition, a small portion of the downstream bandwidth can be devoted to voice rather data, and you can hold phone conversations without requiring a separate line.

Unlike a similar service over your cable TV line, using ADSL, you won't be competing for bandwidth with neighbors in your area. In many cases, your existing telephone lines will work with ADSL. In some areas, they may need upgrading.

CDSL

CDSL (Consumer DSL) is a trademarked version of DSL that is somewhat slower than ADSL (1 Mbps downstream, probably less upstream) but has the advantage that a "splitter" does not need to be installed at the user's end. CDSL uses its own carrier technology rather than DMT or CAP ADSL technology.

G.Lite or DSL Lite

G.Lite (also known as DSL Lite, splitterless ADSL, and Universal ADSL) is essentially a slower ADSL that doesn't require splitting of the line at the user end but manages to split it for the user remotely at the telephone company. This saves the cost of what the phone companies call "the truck roll." G.Lite, officially ITU-T standard G-992.2, provides a data rate from 1.544 Mbps to 6 Mbps downstream and from 128 Kbps to 384 Kbps upstream. G.Lite is expected to become the most widely installed form of DSL.

HDSL

The earliest variation of DSL to be widely used has been HDSL (High bit-rate DSL) which is used for wideband digital transmission within a corporate site and between the telephone company and a customer. The main characteristic of HDSL is that it is symmetrical: an equal amount of bandwidth is available in both directions. For this reason, the maximum data rate is lower than for ADSL. HDSL can carry as much on a single wire of twisted-pair as can be carried on a T1 line in North America or an E1 line in Europe (2,320 Kbps).

IDSL

IDSL (ISDN DSL) is somewhat of a misnomer since it's really closer to ISDN data rates and service at 128 Kbps than to the much higher rates of ADSL.

RADSL

RADSL (Rate-Adaptive DSL) is an ADSL technology from Westell in which software is able to determine the rate at which signals can be transmitted on a given customer phone line and adjust the delivery rate accordingly. Westell's FlexCap2 system uses RADSL to deliver from 640 Kbps to 2.2 Mbps downstream and from 272 Kbps to 1.088 Mbps upstream over an existing line.

SDSL

SDSL (Symmetric DSL) is similar to HDSL with a single twisted-pair line, carrying 1.544 Mbps (U.S. and Canada) or 2.048 Mbps (Europe) each direction on a duplex line. It's symmetric because the data rate is the same in both directions.

UDSL

UDSL (Unidirectional DSL) is a proposal from a European company. It's a unidirectional version of HDSL.

VDSL

VDSL (Very high data rate DSL) is a developing technology that promises much higher data rates over relatively short distances (between 51 and 55 Mbps over lines up to 1,000 feet or 300 meters in length). It's envisioned that VDSL may emerge somewhat after ADSL is widely deployed and co-exist with it. The transmission technology (CAP, DMT, or other) and its effectiveness in some environments is not yet determined. A number of standards organizations are working on it.

x2/DSL

x2/DSL is a modem from 3Com that supports 56 Kbps modem communication but is upgradeable through new software installation to ADSL when it becomes available in the user's area. 3Com calls it "the last modem you will ever need."

DSL SUMMARY TABLE

DSL Type	Description	Data Rate Downstream; Upstream	Distance Limit	Application
IDSL	ISDN Digital Subscriber Line	128 Kbps	18,000 feet on 24 gauge wire	Similar to the ISDN BRI service but data only (no voice on the same line)
CDSL	Consumer DSL from Rockwell	1 Mbps downstream; less upstream	18,000 feet on 24 gauge wire	Splitterless home and small business service; similar to DSL Lite
DSL Lite (same as G.Lite)	"Splitterless" DSL without the "truck roll"	From 1.544 Mbps to 6 Mbps downstream, depending on the subscribed service	18,000 feet on 24 gauge wire	The standard ADSL; sacrifices speed for not having to install a splitter at the user's home or business
G.Lite (same as DSL Lite)	"Splitterless" DSL without the "truck roll"	From 1.544 Mbps to 6 Mbps, depending on the subscribed service	18,000 feet on 24 gauge wire	The standard ADSL; sacrifices speed for not having to install a splitter at the user's home or business
HDSL	High bit-rate Digital Subscriber Line	1.544 Mbps duplex on two twisted-pair lines; 2.048 Mbps duplex on three twisted-pair lines	12,000 feet on 24 gauge wire	T1/E1 service between server and phone company or within a company; WAN, LAN, server access
SDSL	Symmetric DSL	1.544 Mbps duplex (U.S. and Canada); 2.048 Mbps (Europe) on a single duplex line downstream and upstream	12,000 feet on 24 gauge wire	Same as for HDSL but requiring only one line of twisted-pair
ADSL	Asymmetric Digital Subscriber Line	1.544 to 6.1 Mbps downstream; 16 to 640 Kbps upstream	1.544 Mbps at 18,000 feet; 2.048 Mbps at 16,000 feet; 6.312 Mbps at 12,000 feet; 8.448 Mbps at 9,000 feet	Used for Internet and Web access, motion video, video on demand, remote LAN access

RADSL	Rate-Adaptive DSL from Westell	Adapted to the line, 640 Kbps to 2.2 Mbps downstream; 272 Kbps to 1.088 Mbps upstream	Not provided	Similar to ADSL
UDSL	Unidirectional DSL proposed by a company in Europe	Not known	Not known	Similar to HDSL
VDSL	Very high Digital Subscriber Line	12.9 to 52.8 Mbps downstream; 1.5 to 2.3 Mbps upstream; 1.6 Mbps to 2.3 Mbps downstream	4,500 feet at 12.96 Mbps; 3,000 feet at 25.82 Mbps; 1,000 feet at 51.84 Mbps	<u>ATM</u> networks; Fiber to the Neighborhood