Introduction to DSL

Digital Subscriber Line (DSL)

Digital subscriber line is the transmission of digital information, usually on a copper wire pair. Although the transmitted information is in digital form, the transmission medium is usually an analog carrier signal (or the combination of many analog carrier signals) that is modulated by the digital information signal.

Digital subscriber line (DSL) was first used in the 1960s to describe the T-1 circuits that were extended to the customer premises. Later the same term was used to describe ISDN basic rate interface (BRI) (2B+D, 144 Kbps) and primary rates interface (PRI) (23B+D, 1.544 Mbps). There are several different digital subscriber line technologies. Each of these DSL technologies usually has a prefix to indicate the specific variant of DSL technology. Hence, the "x" in xDSL indicates that there are many forms of xDSL technology.

DSL transmission allows high-speed data transmission over existing twisted pair telephone wires. This has the potential providing high-speed data services without the burden of installing new transmission lines (e.g., for Internet access).

DSL service dramatically evolved in the mid 1990s due to the availability of new modulation technology and low cost electronic circuits that can do advanced signal processing (e.g., echo canceling and multiple channel demodulation). This has increased the data transmission capability of twisted pair copper wire to over 50 Mbps.

The data transmission capability of a DSL system varies based on the distance of the cable, type of cable used, and modulation technology. There are several different DSL technologies. Each of the DSL technologies mixes different types of transmission technologies to satisfy a specific business need.

Some DSL systems allow simultaneous digital and analog transmission and are compatible with analog POTS systems.

Figure 1.1 shows a basic DSL system. This diagram shows that the key to DSL technologies is a more efficient use of the 1 MHz of bandwidth available on a single pair of copper telephone lines. A DSL system consists of compatible modems on each end of the local loop. For some systems, the DSL system allows for multiple types of transmission on a single copper pair. This includes analog or ISDN telephone (e.g., POTS) and digital communications (ADSL or VDSL). This diagram shows that there are basic trade offs for DSL systems. Generally, the longer the distance of the copper line, the lower the data rate. Distances of less than 1,000 feet can achieve data rates of over 50 Mbps.

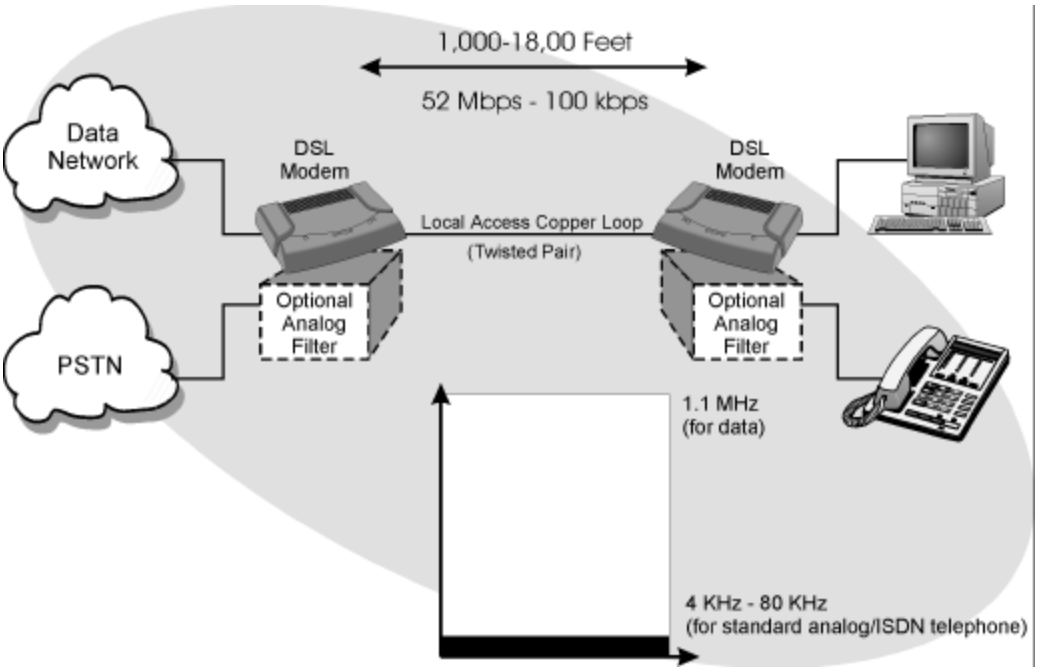

Figure 4.1.1 Basic Digital Subscriber Line (DSL) System

The first digital subscriber lines (DSLs) were developed due to the need for cost effective quality communication over copper wire. The first digital transmission system was the T1 line. This system had a maximum distance of approximately 6,000 feet prior to needing repeaters.

The T1 digital transmission system used a very complex form of digital transmission. A new high-speed digital subscriber line technology was developed to replace T1 transmission technology. HDSL systems increased the distance that high-speed digital signals could be transmitted without the user of a repeater/amplifier. The HDSL system did require 2 (or 3) pairs of wires to allow simultaneous (send and receive) up to 2 Mbps of data transmission. To conserve the number of copper pairs for data transmission, symmetrical digital subscriber line (SDSL) technology was developed. Although SDSL systems offered lower data rates than HDSL, only 2 wire pairs were required. Since SDSL was developed, the HDSL system has evolved to a 2nd generation (HDSL2) that allows the use of 2 wire pair for duplex transmission with reduced emissions (lower egress). New efficient modulation technology used by ADSL systems dramatically increased the data transmission rates from the central office to the customer to over 6 Mbps (some ADSL systems to 8 Mbps). To take advantage of integrated services digital network (ISDN) equipment and efficiency, an offshoot of ISDN technology that was adapted for the local loop was developed. This technology called ISDN digital subscriber line (IDSL). Asymmetric digital subscriber line (ADSL) systems evolved to rate adaptive digital subscriber line (RADSL) allow the data rate to be automatically or manually changed by the service provider. To simplify the installation of consumer based DSL equipment, and low data transmission offshoot of ADSL developed that is called ADSL-Lite. Using similar technology as the ADSL system, very high-speed digital subscriber line (VDSL) was created to provide up to 52 Mbps data transfer rates over very short distances.

Figure 1.2 shows the evolution of DSL systems. This diagram shows that high-speed digital subscriber line technology has been readily available since the 1970s. In the late 1990's, the addition of advanced signal processing technology allowed DSL technology to rapidly increase transmission speed to over 50 Mbps in short distances.

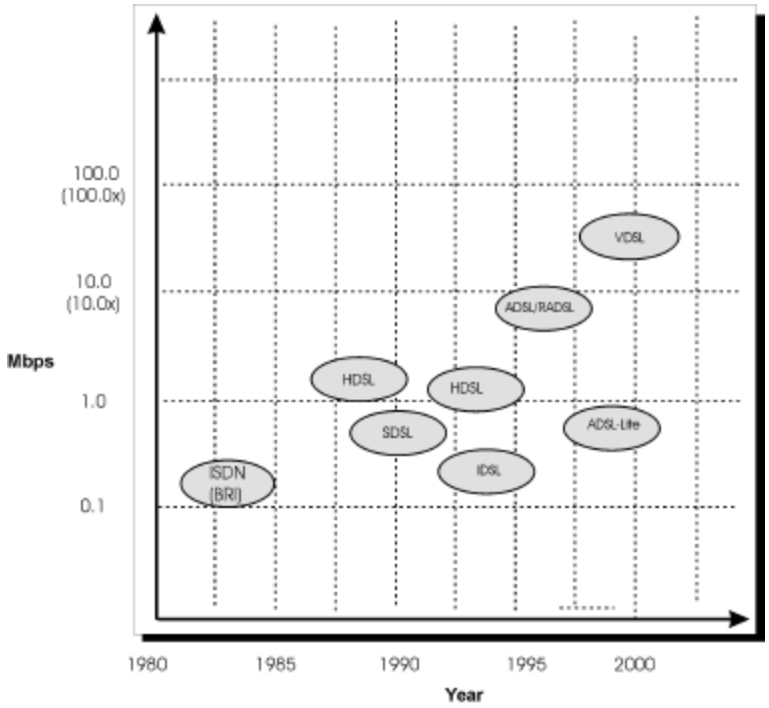

Figure 1.2, Evolution of DSL

High Bit Rate Digital Subscriber Line (HDSL)

High bit rate digital subscriber line is an all digital transmission technology that is used on 2 or 3 pairs of copper wires that can deliver T1 or E1 data transmission speeds. HDSL is a symmetrical service.

Figure 1.3 shows that the first application for HDSL used two pairs (and sometimes 3 pairs) of copper wire. Each circuit has an HDSL Termination Unit (HTU) on each end; an HTU-C (central office) and HTU-R (remote). This example shows that each pair of HDSL wires carries 784 kbps full duplex (simultaneous send and receive) data transmission. To carry the equivalent of a T1 line, two pairs of lines are used. It is also possible to carry an E1 line by using 3 pairs of copper wire. Although the framed transport for HDSL is different than for a T1 or E1 line, the HTU-C and HTU-R convert the protocols to standard T1 lines.

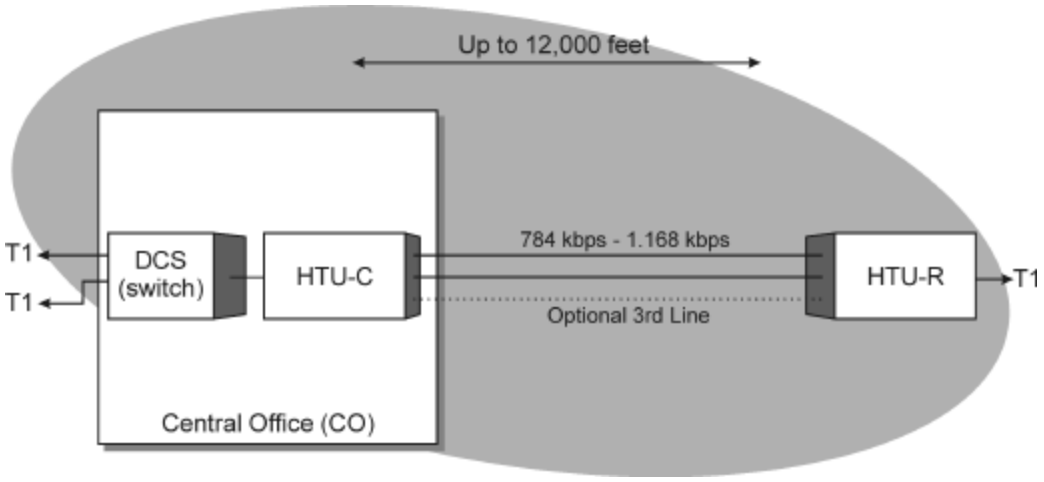

Figure 1.3, High bit rate Digital Subscribe Line (HDSL) System

Asymmetric Digital Subscriber Line (ADSL)

Asymmetrical digital subscriber line (ADSL) is a communication system that transfers both analog and digital information on a copper wire pair. The analog information can be a standard POTS or ISDN signal. The maximum downstream digital transmission rate (data rate to the end user) can vary from 1.5 Mbps to 9 Mbps downstream and the maximum upstream digital transmission rate (from the customer to the network) varies from 16 kbps to approximately 800 kbps. The data transmission rate varies depending on distance, line distortion and settings from the ADSL service provider.

Figure 1.4 shows that a typical ADSL system can allow a single copper access line (twisted pair) to be connected to different networks. These include the public switched telephone network (PSTN) and the data communications network (usually the Internet or media server). The ability of ADSL systems to combine and separate low frequency signal (POTS or IDSN) is made possible through the use of a splitter. The splitter is composed of two frequency filters; one for low pass and one for high pass. The DSL modems are ADSL transceiver unit at the central office (ATU-C) and the ADSL transceiver unit at the remote home or business (ATU-R). The digital subscriber line access module (DSLAM) is connected to the access line via the main distribution frame (MDF). The MDF is the termination point of copper access lines that connect end users to the central office.

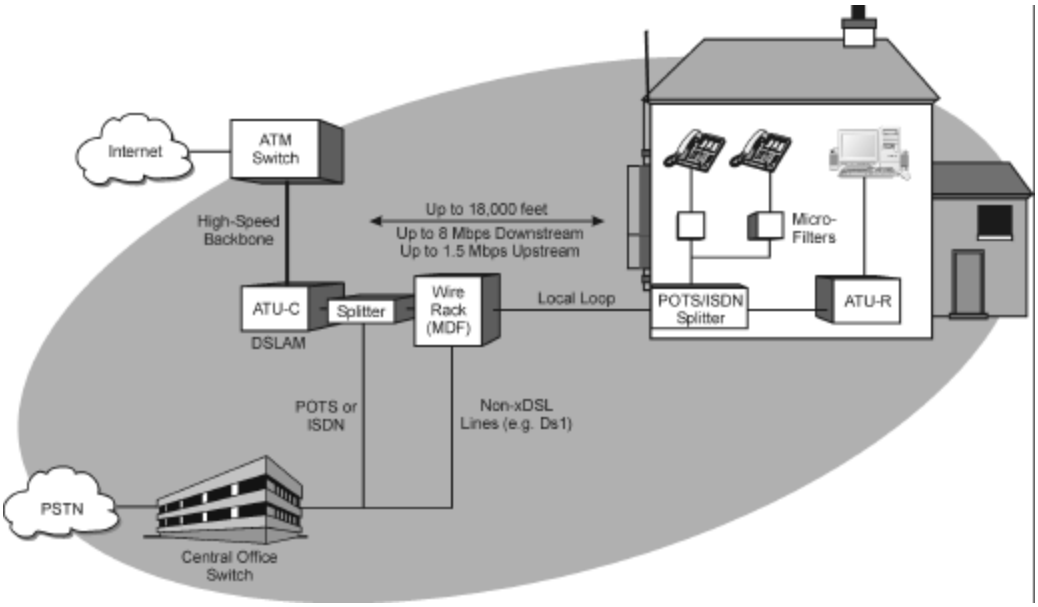

Figure 1.4, Asymetric Digital Subscriber Line (ADSL) System

ADSL-Lite

ADSL-Lite is a limited version of the standard ADSL transmission system. This limited version of ADSL allows for a simpler filter installation that can often be performed by the end user. The limitation of ADSL-Lite is a reduced data transmission rate of 1 Mbps instead of a maximum rate of 8 Mbps.

Figure 1.5 shows that an ADSL-lite system is similar to the ADSL network with the primary difference in how the end user equipment is connected to the telephone network. The ADSL-lite system does not require a splitter for the home or business. Instead, the end user can install microfilters between the telephone line and standard telephones. These microfilters block the high speed data signal from interfering with standard telephone equipment. The ADSL-Lite end user modem contains a filter to block out the analog signals.

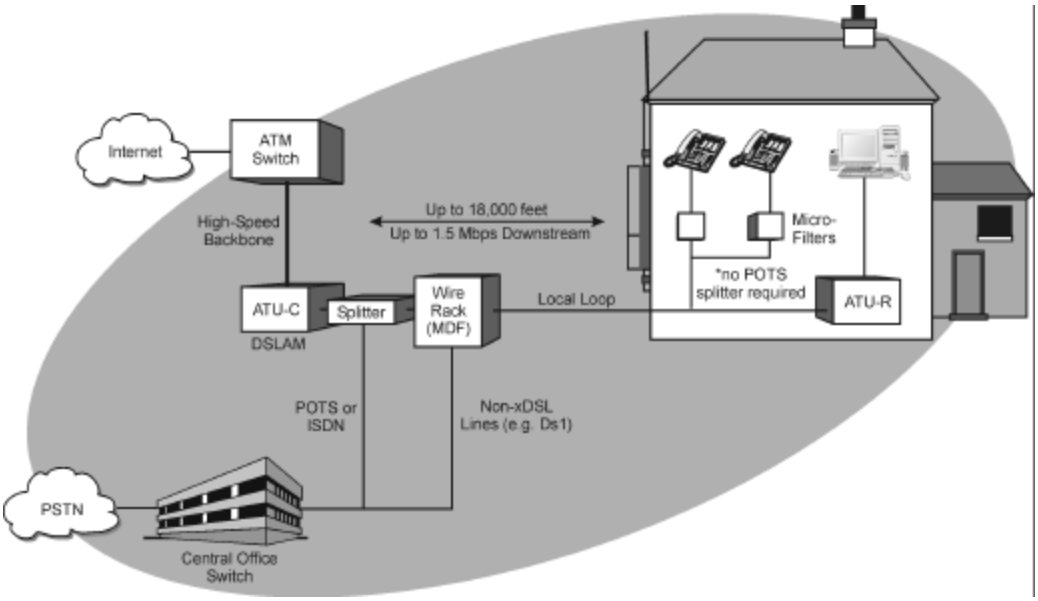

Figure 1.5, ADSL Lite System

Very High Bit Rate Digital Subscriber Line (VDSL)

Very high bit rate Digital Subscriber Line (VDSL) is a communication system that transfers both analog and digital information on a copper wire pair. The analog information can be a standard POTS or ISDN signal and the typical downstream digital transmission rate (data rate to the end user) can vary from 13 Mbps to 52 Mbps downstream and the maximum upstream digital transmission rate (from the customer to the network) can be 26 Mbps. The data transmission rate varies depending on distance, line distortion and settings from the VDSL service provider. The maximum practical distance limitation for VDSL transmission is approximately 4,500 feet (~1,500 meters). However, to achieve 52 Mbps, the maximum transmission length is approximately 1,000 feet (~300 meters).

Figure 1.6 shows how a VDSL system is commonly used with a fiber distribution network that reaches a neighborhood or small group of buildings. The fiber terminates in an optical network unit (ONU). The ONU converts the optical signal into an electrical signal that can be used by the VDSL modem in the DSLAM. The DSL modem signal is supplied to a splitter that combines the analog and digital signal to copper access line. The splitter is actually attached to the last few hundred feet of the copper access line. The figure shows that the analog POTS signal from the local telephone company may still travel thousands of feet back to the central office. At the customers' premises, the VDSL signal arrives to a splitter that separates the analog signal from the high-speed digital VDSL signal. Because VDSL has a much higher data transfer rate, the CPE may include a digital video set top box that allows for digital television.

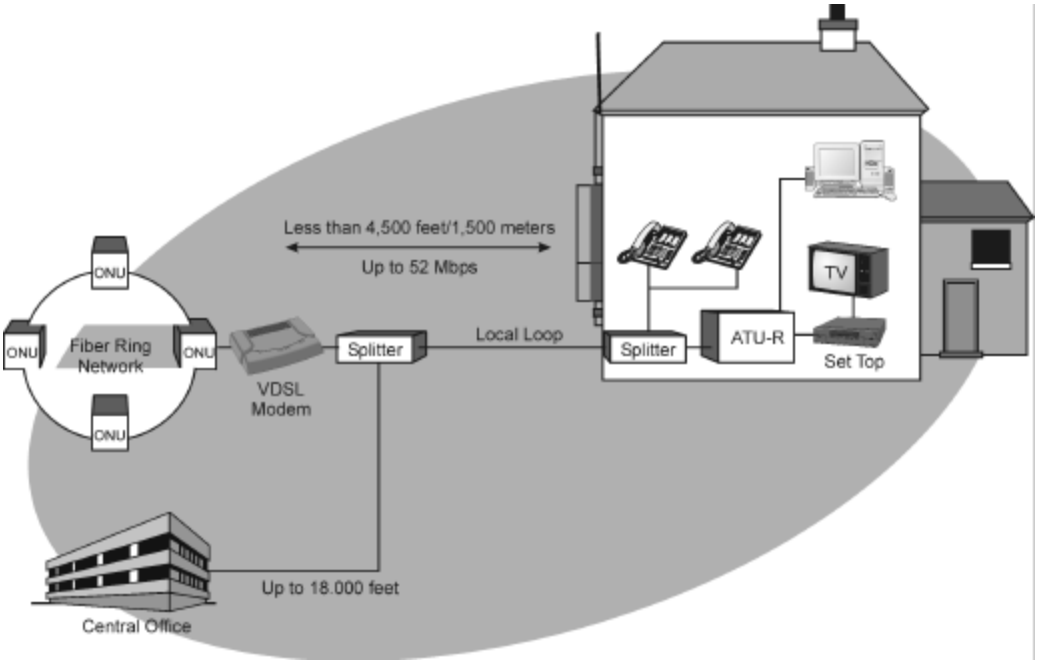

Figure 1.6, Very high bit rate Digital Subscriber Line (VDSL) System