# Broadband Connection

## *DSL vs. Cable Modem*

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# Why the Broadband Connection?

## Broadband Defined

Broadband refers to a communication medium that can be divided into multiple segments that can be used for a variety of purposes.  There are few means of technology that use broadband today.  Some of those means are television, telephone and Internet access.  The definition of broadband is being changed over time, however, the consistently between all the definitions is fast Internet access.

The two types of technologies that push the fast access envelope are Digital Subscriber Line (DSL) and Cable Modem.  Broadband has turned Internet access into a fast, multiple signal technology.  To qualify as a broadband provider, the speed of the service needs to be 200 kbps.

## Dedicated Always-on Connection

Main draws of a broadband connection are that forms of Internet access are advertised as being always on (or always up).  Broadband technologies have provided the Internet world a way to be connected all the time.  All the end user needs to do is select their browser (Microsoft Internet Explorer or Netscape).  DSL and Cable Modem technology is growing industry that provides the ordinary Internet surfer quick and reliable connection.  The always-on connection allows a user to fax or talk on the telephone without interfering with their broadband connection.

Most broadband access methods today don't require use of any ordinary telephone modems, so it's impossible to use the Internet at the same time as the telephone.  Cable modems of course, provide Internet access through the coaxial cable that delivers cable TV signals, so the conventional telephone line can be used for normal talking.  Some forms of DSL coexist in a single line with ordinary use of the telephone line.  Other types of DSL do require a second phone line.

## Consequences with a Dedicated Connection

Although always-on Internet connection has its advantages, it's not without problems.  The worst of these is that you must recognize network security issues.  In addition to the many people who play by the rules, the Internet holds a certain number of troublemakers.  These hackers attempt to break into computers, either for fun or for profit.  Even when you use a dial-up ISP, your computer is vulnerable to break-in; but if you're only online for a few minutes as a time, you risk is greatly reduced.  If your system is constantly available—and especially if it uses the same address at all—your computer becomes a much more appealing target.  Hackers routinely look for vulnerable systems among the Internet address ranges of popular broadband providers.

You might think your system is at minimal risk, even if connected to the Internet at all times, because it contains no enticing data or programs.  Most computer break-ins are dome in order to obfuscate the trail between the hacker and the hackers' true target.  A hacker who breaks into a retailer's credit card database, for instance, might do so through half a dozen or more intermediary systems.  Hackers may also program others' computers to launch automated attacks on target computers, as occurred in early 2000, when major Web sites were temporarily brought down by distributed denial of service (DDOS) attacks.  The security of each end users computer is a very important tool in using and providing always-on connections.

# Broadband over Telephone Lines

## DSL Technologies

*Digital Subscriber Line*

A Digital Subscriber Line makes use of the current copper infrastructure to supply broadband services. A DSL requires two modems, one at the phone companies end and one at the subscribers end. The use of the term modem is not entirely correct because technically a DSL modem does not do modulation/demodulation as in a modem that uses the normal telephone network. DSL' service also has the added benefit of transmitting telephone services on the same set of wire as data services. DSL's common in many flavor, and are sometimes referred to as xDSL, the x standing for the specific type.

For years it has been believed that the upper limit for transmitting data on analog phone lines was 56 kbps. This limit is set using the maximum possible bandwidth and no compression. The reason for this limit is that POTS or Plain Old Telephone Service uses the lower 4 KHz only. The limit imposed by the POTS lines does not take advantage of all the bandwidth available on copper, which is on the order of 1 Mhz. The xDSL technologies take advantage of this difference and use the upper frequencies for data services. Previously this was not possible because of the interference that the data services would cause in the POTS band. Advances in digital signal processing have eliminated the near-end crosstalk that results from the use of the upper bandwidth for data. The new DSP technologies allow data and POTS to be transmitted on the same set of copper wires without interfering with each other. DSL technologies were initially tested for use with video on demand (VOD) and interactive television (ITV) services. Lack of a "killer application" for these services and competition from the cable TV industry in these areas forced the telephone companies to look for a different application for their technologies. With the popularity of the World Wide Web and telecommuting on the rise the DSL technologies moved to providing network and phone services to the home. Other areas where DSL technologies are targeted for are Intranet access, LAN-to-LAN connections, Frame Relay, ATM Network access, and leased line provisioning.

## ADSL

*Asymmetric Digital Subscriber Line*

The most promising of the DSL technologies is ADSL or Asymmetric Digital Subscriber Line. ADSL looks to make the most impact in residential access and the SOHO (Small Office Home Office) market. Just like the name implies ADSL is asymmetric, meaning that the downstream bandwidth is higher than the upstream bandwidth. Downstream refers to traffic in the direction towards the subscriber, and upstream refers to data sent from the subscriber back to the network. This is done because of the kinds traffic that ADSL is designed to carry. Asymmetry is used to increase the downstream bandwidth. This works because all of the downstream signals can be of the same amplitude thus eliminating crosstalk between downstream channels. Upstream signals would have to put up with more interference because the amplitude of the upstream signals would be of smaller amplitude because they originate from different distances. The asymmetric nature of ADSL lends itself well to applications like the web and client server applications.

To achieve the asymmetry ADSL divides its bandwidth into four classes of transport.
- Higher bandwidth simplex channel
- Lower bandwidth duplex channel
- Duplex control channel
- POTS channel

Transmission on the high bandwidth simplex channel and the lower bandwidth duplex channel do not interfere in any way with the POTS channel. So ADSL can carry both data a POTS on the same medium, which makes it ideal for residential and small office use.

ADSL bandwidth is currently standardized by ANSI (American National Standards Institute). Tables 1 and 2 detail the four transport classes that are based on multiples of T-1 (1.5 Mb/s) downstream bandwidth. There are also three more classes that are based on the European E-1 (2.0 Mb/s) standard, which is shown in the second chart. These classes are all based on the maximum bandwidth available on each channel. The actual rates depend on factors such as wire gauge, local loop length, and line condition. In this case, the local loop length is the distance from the central office to the subscriber.

**ADSL Transport Classes** (T-1 based multiples)*

| Class | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Downstream simplex channel | 6.144 Mb/s | 4.608 Mb/s | 3.072 Mb/s | 1.536 Mb/s |
| Upstream duplex channel | 640 kb/s 576 kb/s of usable bandwidth | 608 kb/s 544 kb/s of usable bandwidth | 608 kb/s 544 kb/s of usable bandwidth | 176 kb/s 160 kb/s of usable bandwidth |
| Control channel | 64 kb/s | 64 kb/s | 64 kb/s | 16 kb/s |
| POTS channel | 64 kb/s | 64 kb/s | 64 kb/s | 64 kb/s |

**Chart 1**
**ADSL Transport Classes** (E-1 based multiples)*

| Class | 2M1 | 2M2 | 2M3 |
|---|---|---|---|
| Downstream simplex channel | 6.144 Mb/s | 4.096 Mb/s | 2.048 Mb/s |
| Upstream duplex channel | 640 kb/s | 608 kb/s | 176 kb/s |
| Control channel | 64 kb/s | 64 kb/s | 16 kb/s |
| POTS channel | 64 kb/s | 64 kb/s | 64 kb/s |

**Chart 2**
*Table information from *IEEE Network Jan./Feb. 1997*

## Competing Standards

One issues yet to be resolved with ADSL is the debate between CAP (Carrierless Amplitude Modulation) and DMT (Discrete Multitone) line code standards. DMT has been standardized by ANSI, but currently various companies have released products using CAP. Different companies support different standards and neither of them has become a de facto standard. CAP technologies have been quicker to get to market but DMT is gaining. The main drawback with DMT is that it has been expensive to deploy up until recently. Both methods have their advantages. CAP is a single carrier modulation technique that uses three frequency ranges. CAP uses 900 MHz for downstream data, 75 MHz for upstream data, and 4 kHz for POTS service. CAP takes the data channels and treats them like one big pipe on which to send data. DMT is different in that it breaks the data transmission channels into 256 subchannels and then selects the best ones on which to send its data. DMT fits better in to a RADSL or Rate Adaptive DSL; scheme due to the fact that it has that ability to select channels that have lower levels of interference on them. CAP generally provides 1.5 Mb/s downstream and 64 kb/s up stream. In contrast DMT transmits 6 Mb/s downstream and 640 kb/s upstream. DMT is not without disadvantages, the DMT equipment requires more power and therefore operates at higher temperature which limits the number of ADSL / DMT modems that can be stacked together at a central office.
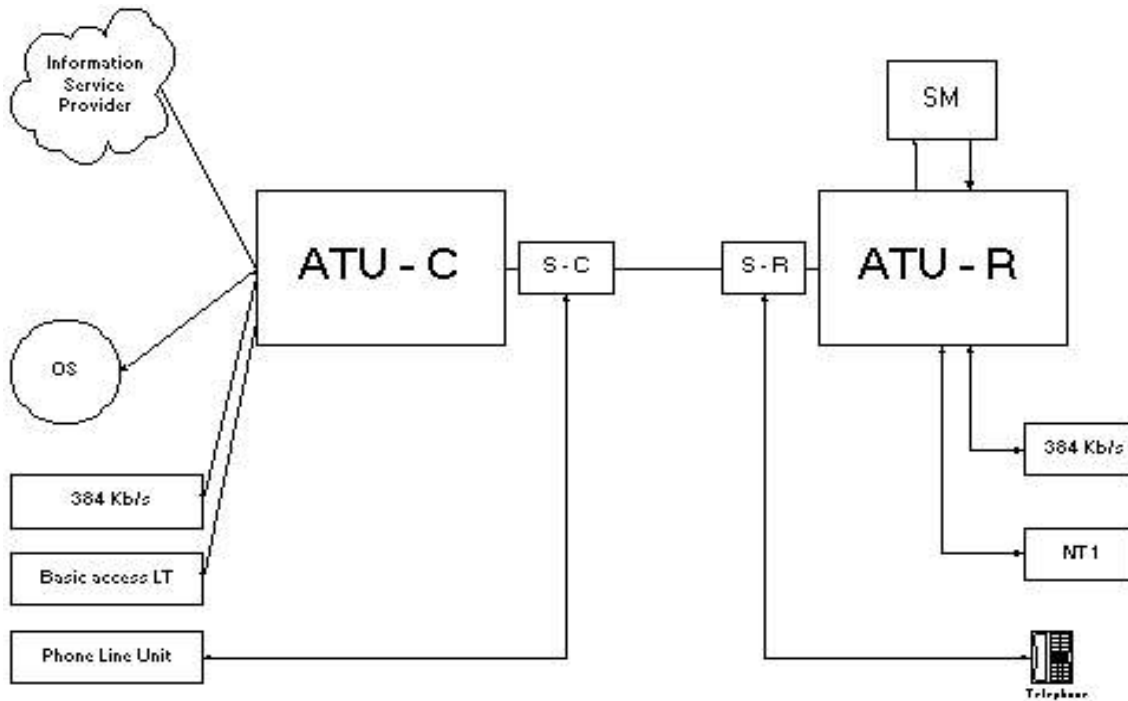
**Figure 1: Basic ADSL system**

The basic ADSL model is given in figure 1. The -C and -R designations are given to the terminal equipment on the Central Office and the remote end respectively. The S-C and the S-R units split the POTS signal in and out of the ADSL signal.

## Trends

Of all the DSL technologies ADSL in being tested the most right now. Widespread deployment is not far off. To help this along companies are making complete DMT based ADSL transceivers on a chips at lower costs than the chip sets previously used. Some of those chips also incorporate Ethernet serial transceivers in them to make it easier to interface with current LAN technologies.  There is also some debate between HDSL or High-data-rate DSL and ADSL. HDSL provides a symmetric data pathway at 1.544 Mb/s which matches the speed of today's T-1's. HDSL has been around longer and is currently being used to effectively provision local access to T-1's. HDSL has it place in that market while ADSL can provide a better service to homes and small business that use the web and client server technologies.

# The DSL Family

## HDSL

*High-data-rate Digital Subscriber Line*

The most common DSL deployed today is HDSL. Telephone companies mostly use HDSL to provision other services. HDSL symmetrically delivers 1.544 Mb/s over two sets of copper twisted pair. Which is the same rate as a T-1 type connection. This allows Telco's (short for telephone companies) to use HDSL to deliver T-1 services. HDSL's operating range is about 12,000 feet, and it is possible to extend that by using repeaters along the line to the customer. HDSL is mostly used to deploy PBX network connections, interexchange POP's (Point Of Presence), and directly connecting servers to the Internet.

## SDSL

*Single-line Digital Subscriber Line also know as Symmetric Digital Subscriber Line*

Similar to HDSL, SDSL delivers the same 1.544 Mb/s, but it does it on a single set of twisted pair of copper. This limits SDSL's reach to 10,000 feet. SDSL could take hold in niche markets like residential video conferencing or connecting LAN's over short distances.

## VDSL

*Very-high-rate Digital Subscriber Line*

VDSL technology operates on a single set of copper twisted pair, and delivers data in the range of 13 Mb/s to 52 Mb/s. This high bandwidth does not come without a price; the range of VDSL is limited to between 1,000 and 4,500 feet. The VDSL standard is still in the works but there are already applications for the technology. One use for it is in getting high data rate services from the telephone companies central office to the subscriber via a FTTN (Fiber To The Neighborhood) network. FTTN encompasses the Fiber To The Curb technologies and uses VDSL as the customers' connection to the telephone company's fiber based network.  VDSL would be used to connect premises distribution networks to the Optical Network Unit or ONU. The optical network unit is in turn connected via fiber optical line to the Telco's central office.
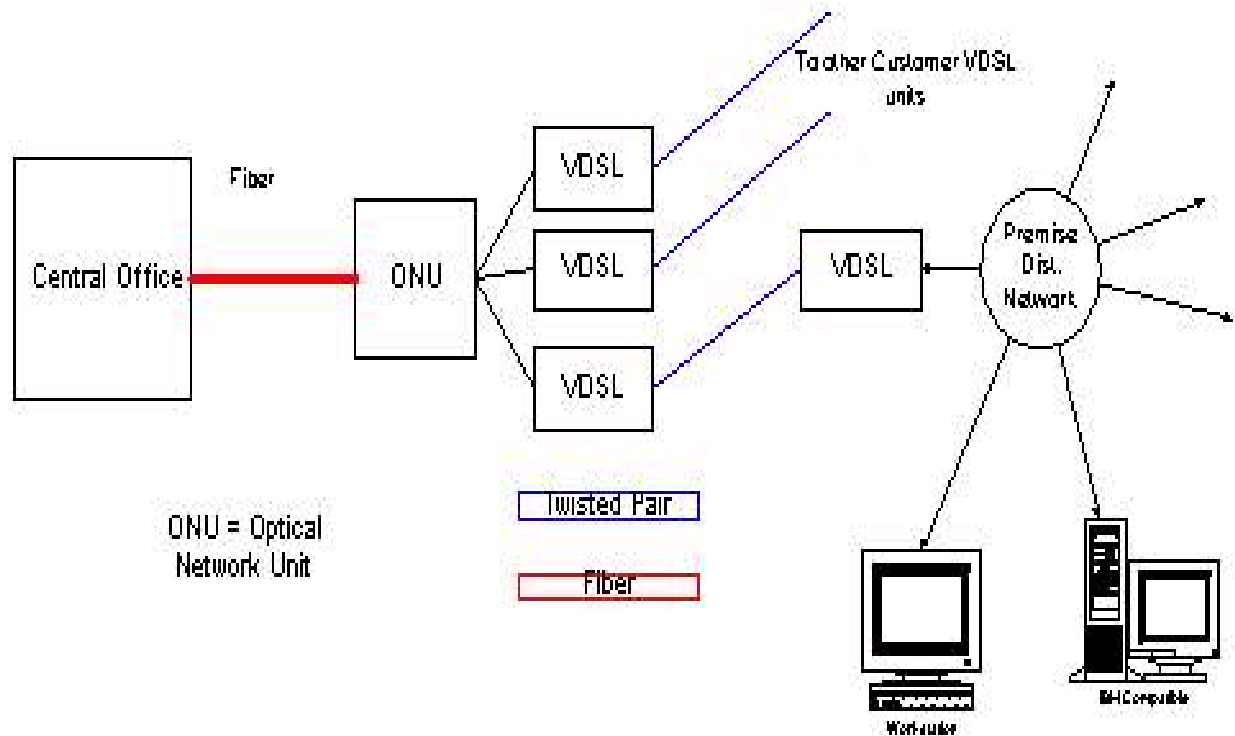


**Figure 2: A typical use of VDSL**

Figure 2 shows how VDSL might be used to bring data services from an ONU to the customer's premises distribution network. The fiber links are shown in red and the twisted pair links are shown in blue.  Since VDSL is still in discussion right now there are no solid standards but the ADSL Forum has set some reachable goals in an early draft. Data rates have been projected as multiples of SONET and SDH. These speeds have been chosen because of proposed use of VDSL as a solution for delivering fiber type bandwidth to customers over copper.

**Proposed Data rates for VDSL**

| Data rate | Range in feet | Range in meters |
|---|---|---|
| 12.96 - 13.8 Mb/s | 4500 ft | 1500 m |
| 25.92 - 27.6 Mb/s | 3000 ft | 1000 m |
| 51.84 - 55.2 Mb/s | 1000 ft | 300 m |

# RADSL

*Rate Adaptive Digital Subscriber Line*

RADSL is derived from ADSL technologies with some added features. RADSL automatically adjusts line speed based on the condition of the line. In areas where there is a large variance in the distance between the central office and the subscribers RADSL helps to provide a more consistent service for it's subscribers by taking the uncertainties of line conditions out of the equation when setting up a DSL connection. RADSL can adjust line speed based on the gauge of the wire, the distance between subscriber and the central office, and the condition of the line. It also takes care of fluctuations that the weather can induce into the line.

# Comparison of DSL Technologies

| DSL | Upstream Bandwidth | Downstream Bandwidth | Range | Media | Symmetry |
|---|---|---|---|---|---|
| ADSL | 16 kb/s to 640 kb/s | 1.5 Mb/s to 9 Mb/s * | 18, 000 feet | Single twisted pair | Asymmetric |
| HDSL | 1.544 Mb/s | 1.544 Mb/s | 12, 000 feet | Two twisted pairs | Symmetric |
| SDSL | 1.544 Mb/s | 1.544 Mb/s | 10,000 feet | Single twisted pair | Symmetric |
| RADSL | varies with in ADSL range | varies with in ADSL range | 18,000 feet | Single twisted pair | Asymmetric |
| VDSL | 13 Mb/s - 52 Mb/s | 1.6 Mb/s to 2.3 Mb/s | 1,000 - 4,500 ft | Single twisted pair | Both |

**Chart 4**
* New technologies have reported higher rates.

# Broadband over Coax

## Cable Technologies

*Broadband networking using a modification of toady's CATV infrastructure.*

Internet growth and the convergence of the television with the computer has led cable companies to develop methods of delivering broadband services to residential customers. Currently there are approximately 63 million households in the United States that have cable TV. That number is projected to grow to near 70 million by the year 2000. It is estimated that about 40% of those households are in a cable system that, with modest upgrade to the backbone equipment, will be able to support two-way cable network traffic. This opens up a huge market for cable companies. Cable modem bandwidth varies with the manufacturer of the equipment and the network design from 96 kb/s up to 10 Mb/s. Cable networks are based on modified LAN technologies and the Hybrid Fiber Coax (HFC) network, which accounts for the backbone of most modern cable systems. The one major drawback to this strategy is that these networks are all based on media sharing. This only presents a problem when the network is under heavy use, but with proper network design overloading can easily be avoided.

### Basic Model of Operation

Cable modems have been designed to transparently carry data traffic through a combination of HFC and or coax network then connects to varying types of data networks. Beyond transparently carrying IP traffic a cable modem network must also be capable of filtering certain types of traffic. The cable network must be able to filter out all local LAN broadcasts, except for DHCP traffic that is used to configure network hosts, and ARP packets that are needed for address resolution. Also ICMP message must be passed over the network for the proper use of the IP protocol. A specification for the cable modem to customer network equipment has been established by a group of companies and maintained by Cable Labs a Denver based R&D Consortium. Some of the companies in this working group are Comcast, Continental Cablevision, Cox Communications, Rogers Cablesystems Ltd, Time Warner Cable, and Tele-Communications Inc. They also set specifications for the network termination equipment that interface the cable network and other data networks. This specification specifies interfaces for several different kinds of data network some of those are ATM, FDDI, Ethernet and IEEE 802. Protocols.
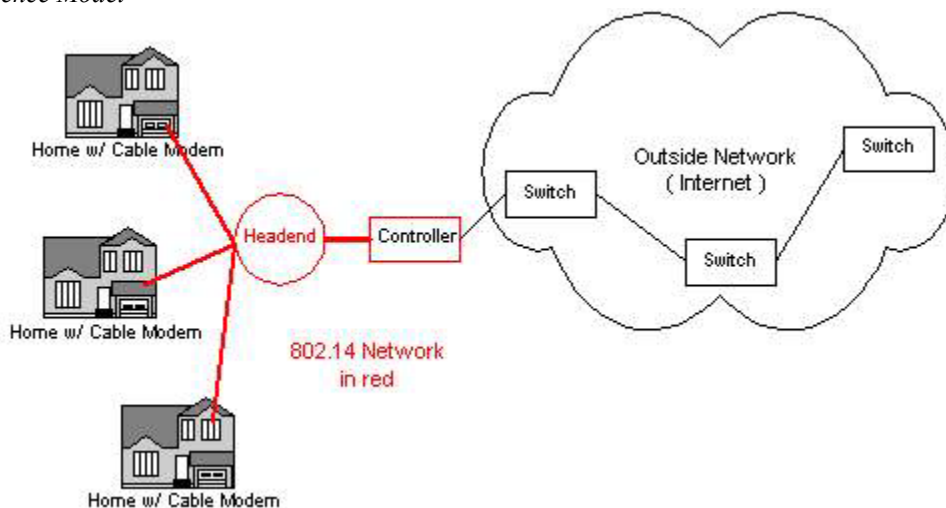
### IEEE 802.14

*Logical Reference Model*



**Figure 3: An 802.14 network is shown in red**

The model shown in figure 3 will be implemented over HFC and TV cable coax networks. The topology of todays most common cable TV system is tree and branch or a collection of branches, where all signals originate at the head and are propagated down to the subscribers. The IEEE 802.14 standard provides for several different topologies, coaxial cable TV network, fiber to the serving area, regional hub / passive coaxial network, and hybrid fiber coax networks. IEEE 802.14 also makes certain network inter-connectivity requirements. Inter-network communication on an 802.14 network is when a host transmits upstream to the headend and then on to another 802.14 network. If the sender and receiver are on the same branch of the network then the upstream traffic can be broadcast and all hosts on that network will receive it. In the event that the destination is not on the same network the headend can forward it on the to correct 802.14 network. This brings in the need for inter-headend communications. This is accomplished by linking 802.14 headends together using point-to-point SONET links, ATM switches, IEEE 802.6 shared buses, or SONET rings. The 802.14 MAC layer is designed to be a fair and open protocol layer. Traffic control is used to provide fair access to network services. The traffic control services to be offered on an 802.14 network are deadlock avoidance and congestion control. Call admittance algorithms are used to reject calls after the constant bit rate bandwidth has been exceeded. Support for asymmetry is also included in the 802.14 standard as a way to better support traffic that requires greater bandwidth in one direction, like VOD, POTS, and video telephony. For these types of applications to work some methods of synchronous communications are needed, constant bit rate and variable bit rate services provide this. These services are synchronous in that periodic access to the medium needs to be guaranteed in order to maintain quality of service.

# Cable Family

As you can see from the DSL marketplace, there are a half a dozen different common forms of DSL service.  The cable marketplace also supports several different forms of service, but the industry is rapidly converging on a single standard known as the Data over Cable Systems Interface Specifications (DOCSIS).  This theoretically makes purchasing cable service easier, but in 2001 competing forms of cable technology still hold enough sway that it's important you understand what you're getting.

## One-Way Cable

Some very old cable systems provide what's known as one-way or telephone return service.  The cable TV infrastructure was built with transmission from the headend in mind, but return traffic wasn't originally considered important.  Even prior to the advent of cable Internet access, though, cable operators upgraded their systems to accept a small amount of upstream traffic – mainly for pay-per-view ordering and limited interactive features.  Nonetheless, it's simpler to design a cable Internet access system that does not require the cable modem to send large amounts of data back to the headend.  Therefore some early cable modem designs used the cable system only for downstream data.  Upstream data go out over a conventional dial-up telephone modem.  In these systems, either telephone modem can be connected to the cable modem and require no special configuration on the host computer, or it can be connected to the computer, requiring special software.

One-way cable systems, although simpler to design than two-way systems, are much less desirable from the consumer's point of view.  The one-way arrangement does not break one's dependence on the telephone network, so you must still tie up a voice telephone line or obtain a second, data only phone line.  A one-way system isn't always up, and there's a delay associated with the initiating Internet access.  Although a one-way system can achieve true broadband speeds downstream, upstream speeds are limited to those of a telephone modem.

## Two-Way Cable

As the name implies, a two-way cable system can both send and receive data. Sending data on a shared medium such as a cable TV network poses some very real technical challenges. Consider a situation in which two subscribers try to send data at the same time.  The result is what's known as a collision; the headend receives both subscribers' packets at once and can understand neither.  Given the size of cable networks, collisions might seem unavoidable.  The technology avoids collisions, however, through a careful use of timing.  The headend tells each cable modem when it may or may not transmit data, giving slices of the network's time to each subscriber in turn.  You don't notice the interleaved nature of this network access because the time slices are so small.  Downstream data transmission isn't a problem because it all originates from one point – the headend.  The headend can simply schedule each subscriber's downstream traffic as it sees fit.

Various systems for implementing two-way cable networks have been developed and sold by companies such as Motorola, and Terayon.  The industry has largely settled on just on standard system, though: DOCSIS.  In 2001, DOCSIS – compliant modems are available from wide variety of manufacturers, such as Toshiba, and 3Com, and others.  For the most part, these modems are interchangeable, although you must inform your cable company if you change modems.  Many cable companies rent cable modems to their cable customers, but many allow you to buy your own, often giving the customer a reduction in the monthly service costs.  On the whole, renting seems the better choice in 2001, although this may change in a couple of years if the technology stabilizes a bit.  Like most cable technologies and some forms of DSL, DOCSIS is an asymmetrical protocol – it allows for much higher downstream speeds than upstream speeds.  DOCSIS permits the cable operator to program the modem to implement speed caps.

# Broadband: DSL vs. Cable Modem

## Comparison

These two services are competing for consumers based on availability, security, speed, and reliability and finally price.  I've described the two types of technologies over the past few sections of this paper. Now that there is a clean understanding of what each service is, let's compare the two.

### Availability

The first component is availability. One of the main disadvantages of DSL service is that only systems within 3 to 4 miles of a telephone central office can use DSL.  Since, cable doesn't have a distance limitation of DSL, cable modem service is generally ideal for homes that are already wired for cable TV. Many businesses use DSL because many of the offices and buildings are not wired with coax.  Also, many of the cable modem service providers do not offer a strong business related Internet service.

### Security

The next competing component is security.  Security is always a main concern when dealing with the Internet.  Many people are concerned about how secure cable modems actually are, since they are operated on a shared system.  Cable Internet service shares bandwidth with 100 or more cable TV channels.  The service is broadcast across the shared system.  The cable modem technology recognizes the signal that is meant for the particular customer.  DSL service, on the other hand, is inherently more secure than using a cable modem because DSL provides a dedicated connection across a existing telephone line.

### Speed

Speed is always a major concern with Internet providers and users.  Dedicated connection to the Internet blurs the boundary between when your computer ends and the Internet begins.  Both Cable Modem and DSL provide download transfer rates more then twice as fast as a 56 Kbps modem.  Cable modems are capable of receiving data at 3 mbps to 10 mbps.  However, the speed seems to be slower when data is sent upstream.  One downfall is the transfer rate will drop if everyone on your street logs on at the same time.  DSL gives users dedicated bandwidth. However, the proximity between your DSL connection and the CO (central office) will factor into your speed.  People that live closer to the CO will receive data rates up to 6.1 mbps.

Keynote systems, a recognized authority on Internet performance, completed a bandwidth test that showed a very modest DSL service (offered 384 kbps downstream and 128 kbps upstream) actually out performed cable during the peak hours of 5pm to 11pm.  While bandwidth on the Internet is ultimately always shared at some point, it seems that cable modem service has become the leader in the always-up connection.

### Reliability

When it comes to reliability, people voice justifiable concern that their local cable company doesn't offer a high-quality television service, so it seems even more doubtful that they will provide a high quality Internet

service.  The telephone company, on the other hand, has been providing high-quality, uninterrupted service to its customers for years.

Another aspect that people pay attention to in terms of reliability is the amount of time a service has been available. DSL technologies, on the whole, are only about 2 years old.  Cable modem technologies, on the other hand, are at least 7 to 8 years old. Cable modems, which deliver Internet access over a cable television connection, are far better established. There are nearly 1 million cable modem users compared to 4.1 million DSL lines in North America.

# Price

Finally, these two technologies are competing on price. Cable modem Internet access is reasonably prices. You can get a cable connection fro $30 to $50 per month.  Plus, this price usually includes services such as email and newsgroups.  In addition the actual cable modem that is necessary in order to receive the Internet service is usually either provided to the customer by the cable provider or can be purchased by the customer.  DSL connection cost, on the other hand, ranges from $20 to $80 per month, many times that don't ever included Internet access. Plus, DSL modems are proprietary and usually are pretty costly.

One of the reasons that cable modem service costs less than DSL is because it's a shard facility.  A coaxial cable traveling in a neighborhood from house to house can provide high-speed service to thousands of customers. A single piece of equipment at the cable companies headend can connected those thousands of customers onto the Internet.  DSL requires a separate pair of wires fro each subscriber.  The company must install a special DSL modem fro each phone line at the CO.  Cable modem services likely will be the suitor for now as it is cheaper.   The DSL market invites more competition than does cable. This means that DSL prices in the future should drop.

**Table 1: DSL and Cable Pros and Cons**

| DSL | | Cable Modem | |
|---|---|---|---|
| Pros | Cons | Pros | Cons |
| Always on. | Setup can be difficult | More widespread than DSL. | Less secure than DSL. |
| Far faster then 56Kbps dial-up modem. | Performance depends on location. | Potentially faster than DSL. | Line shared with others in the neighborhood speeds may vary |
| Better security than cable | For business users, higher speeds get pricey | Price break if you get cable TV service, too. | |

**Table 2: Price and Speed**

| | Installation Fee | Monthly Rates | Speeds |
|---|---|---|---|
| DSL | $100 to $200 | $40 to $80 for home users | ADSL: 384 kbps to 9 mbps download/ 128 kbps upload |
| | | $80 to $320 for business users | SDSL: 1.5 mbps download/upload |
| Cable Modem | $75 to $200 | $39.95 to $49.95 | 1 to 2 mbps download/ 128 kbps to 384 kbps upload. |

# Providers

### DSL ISPs

If you want to get a DSL broadband connection, you may be wondering where to go to find what you need.  Typically DSL ISP's (Internet Service Provider) provide a modem as part of a start-up package, but you might want to pass on the default service in favor of something with more features. In 2001, literally hundreds of ISP's offer DSL service. It's therefore impossible to provide anything resembling a complete list of providers. Here is a short list of some DSL's heavy hitters:

- AT&T
- SBC Communications
- Sprint
- Qwest
- Verizion

### Cable ISPs

In 2001, just two companies dominate the cable Internet access industry: Excite@Home and Road Runner.  These companies are both owned, in part or in whole, by large cable companies, which tend to use their services. On occasion, though, one cable company purchases another or bus out individual franchises, which might have used another ISP.  In such cases, the new owner might continue to use the current ISP or change.  There are also a few cases of cable operators offering a choice of ISP, although usually a very limited choice. Some the heavy hitters that support both of these cable Internet access providers are:

- AT&T Broadband
- Cox Communications
- Adelphia
- Comcast
- Charter Communications
- AOL/Time Warner

In addition to Excite@Home and Road Runner, several smaller ISPs operate in the cable field.  Some of these are closely affiliated with specific cable companies or are the same as those companies.  A few dial-up companies have joined into the broadband market, however are still struggling to survive.

## Markets

In this section, you find the most up to date information regarding DSL and Cable modem market share. Both DSL and Cable is article from strategic analysis companies that provide this information to the government and all providers of each service.  The analysis will provide a comparison between DSL and Cable modem markets through Q3 of 2001.

North American cable multi-system operators (MSOs) trounced telecom competitors in the third quarter, adding more than twice as many residential broadband Internet subscribers. According to Cable Datacom News publisher Kinetic Strategies Inc., North American MSOs added 1.016 million subscribers in Q3, there best quarter ever, compared to a lackluster 450,889 residential DSL additions. Over the last four calendar quarters, MSOs have added 3.9 million cable modem customers, compared to 1.9 million DSL additions.

**Residential Broadband Subscriber Additions in North America**
Source: *Kinetic Strategies, Inc.*

|  | Cable | DSL | Total |
|---|---|---|---|
| Q3 2001 | 1,016,566 | 450,889 | 1,467,455 |
| Q2 2001 | 888,809 | 334,576 | 1,223,385 |
| Q1 2001 | 1,008,111 | 560,148 | 1,568,259 |
| Q4 2000 | 1,016,126 | 591,872 | 1,607,998 |
| Total | 3,929,612 | 1,937,485 | 5,867,097 |
| Share | 67% | 33% | 100% |

As of September 30 MSOs served 7.6 million subscribers, more than double the 3.3 million residential DSL customers connected by telecom. Including fixed wireless and satellite subscribers, total residential broadband connections topped 11 million at the end of calendar Q3.

Kinetic Strategies estimates total cable modem connections reached 8 million by December 1, compared to 3.6 million DSL subscribers. The end of 2001 projects these totals to reach 8.5 million and 3.7 million, respectively. Approximately 70 percent of all cable homes passed in North American are now marketed for cable modem service.

**Residential Broadband Subscribers in North America**
Source: *Kinetic Strategies, Inc*

| Q3 2001 Statistics | Residential DSL | Cable Modem | Total |
|---|---|---|---|
| U.S. Subscribers 9/30/01 | 2,687,100 | 6,220,462 | 8,907,562 |
| Canada Subscribers 9/30/01 | 647,162 | 1,395,538 | 2,042,700 |
| N. American Subs 9/30/01 | 3,334,262 | 7,616,000 | 10,950,262 |
| N. American Share 9/30/01 | 30.45% | 69.55% | 100.00% |
| N. American Q3 Sub Adds/Week | 34,684 | 78,197 | 112,881 |
|  |  |  |  |
| Estimated Statistics 12/1/01 | Residential DSL | Cable Modem | Total |
| U.S. Subscribers | 2,918,612 | 6,731,039 | 9,649,651 |
| Canada Subscribers | 717,746 | 1,476,226 | 2,193,972 |
| N. American Subscribers | 3,636,358 | 8,017,265 | 11,653,623 |

**Cable Modem and DSL Subscribers by Carrier in North America**
**as of September 30, 2001**
Source: *company reports, Kinetic Strategie*s

| U.S. MSO | CM Subs |  | U.S. Telecom | DSL Subs |
|---|---|---|---|---|
| AT&T | 1,387,000 |  | SBC | 1,187,000 |
| Time Warner Cable | 1,661,000 |  | Verizon | 985,000 |
| Comcast | 792,700 |  | Qwest | 405,000 |
| Charter | 507,700 |  | BellSouth | 463,000 |
| Cox | 779,499 |  | Broadwing | 59,000 |
| Adelphia | 315,104 |  | Covad | 346,000 |
| Cablevision | 423,100 |  | **Total U.S.** | **3,445,000** |
| Mediacom | 95,000 |  | Residential | 2,687,100 |
| Insight | 95,000 |  | Business | 757,900 |

| | CM Subs | | Canadian Telco | DSL Subs |
|---|---|---|---|---|
| RCN | 104,359 | | Bell Canada | 625,000 |
| Other | 60,000 | | Telus | 157,000 |
| **Total U.S.** | **6,220,462** | | Manitoba | 26,953 |
| **Canadian MSO** | **CM Subs** | | **Total Canada** | **808,953** |
| Rogers | 422,600 | | Residential | 647,162 |
| Shaw | 625,000 | | Business | 161,791 |
| Videotron | 200,000 | | **Total North America** | **4,253,953** |
| Cogeco | 107,938 | | Residential | 3,334,262 |
| Other | 40,000 | | Business | 919,691 |
| **Total Canada** | 1,395,538 | | | |
| **Total North America** | **7,616,000** | | | |

## Up and Coming Competition

DSL and cable systems dominate the market for broadband Internet access. There are not the only available options, however, the others may in time overtake their market leaders. In the past few years, several companies have rolled out broadband service based on radio technologies, using both ground-based and orbiting transmitters. These services are inexpensive to deploy, compared with new cable-based services, but at present they suffer from certain drawbacks. Ground-based services are rare, and satellite-based services suffer from high latencies and (for some) the need for a telephone return path. Nonetheless, these services fill certain niches in the marketplace and may become more important in the future as LEO satellites and additional ground-based transmitters come online.

In the wired world, fiber-optic technologies hold the promise of unprecedented amounts of bandwidth delivers to offices and homes. These technologies are likely to become important as utilities upgrade infrastructure and in some cases as new companies deploy fiber networks to compete with entrenched cable and telephone company networks.

# Glossary

**A**

**ADSL** - See Asymmetric Digital Subscriber Line.

**algorithm** - A specific procedure used to modify a signal. For example, the key to a digital compression system is the algorithm that eliminates redundancy.

**analog** - A continuously varying signal or wave. As with all waves, analog waves are susceptible to interference which can change the character of the wave.

**asymmetric digital subsciber line (ADSL)** - A group of DSL technologies that reserve more bandwidth in one direction than the other, which is advantageous for users that do not need equal bandwidth in both directions. See DSL.

**asynchronous** - Occuring at different times. For example, electronic mail is asynchronous communication because it does not require the sender and receiver to be connected at the same time.

**asynchronous transfer mode (ATM)** - A method of data transportation whereby fixed length packets are sent over a switched network. The ability to ensure reliable delivery of packets at a high rate makes it suitable for carrying voice, video, and data.

**B**

**backbone** - The part of a communications network that handles the major traffic using the highest-speed, and often longest, paths in the network.

**bandwidth** - A measure of capacity of communications media. Greater bandwidth allows communication of more information in a given period of time. Bandwidth is generally described either in terms of analog signals in units of Hertz (Hz), which describes the maximum number of cycles per second, or in terms of digital signals in units of bits per second.

**basic rate ISDN (BRI-ISDN)** - The basic rate ISDN interface provides two 64 Kb/s chan-nels (called B channels) to carry voice or data and one 16 Kb/s signaling channel (the D channel) for call information.

**broadband** - An adjective used to describe large-capacity networks that are able to carry several services at the same time, such as data, voice, and video.

**C**

**CAP** - See Carrierless Amplitude Phase

**carrier** - an electromagnetic wave or alternating current which is modulated to carry signals in radio, telephonic, or telegraphic transmission.

**carrierless amplitude phase (CAP)** - A type of quadrature amplitude modulation, used for some types of DSL, that stores pieces of a modulated message signal in memory and then reassembles the parts in the modulated wave.

**central office (CO)** - A telephone company facility that handles the switching of telephone calls on the public switched telephone network (PSTN) for a small regional area.

**central processing unit (CPU)** - The "brains" of a computer, which uses a stored program to manipulate information.

**circuit-switched network** - A type of network in which a continuous link is established between a source and a receiver. Circuit switching is used for voice and video to ensure that individual parts of a signal are received in the correct order by the destination site.

**CO** - See central office

**competitive local exchange carrier (CLEC)** - An American term for a telephone company that was created after the Telecommunications Act of 1996 made it legal for companies to compete with the ILECs. Contrast with ILEC.

**CLEC** - See competitive local exchange carrier.

**compression** - The process of reducing the amount of information necessary to transmit a specific audio, video, or data signal. core network - The combination of telephone switching offices and transmission plant connecting switching offices together. In the U.S. local exchange network, core networks are linked by several competing Interexchange networks; in the rest of the world the core network extends to national boundaries.

**crosstalk** - Interference from an adjacent channel.

**D**

**dedicated connection** - A communication link that operates constantly.

**dial-up connection** - A data communication link that is established when the communication equipment dials a phone number and negotiates a connection with the equipment on the other end of the link.

**digital signal** - A signal that takes on only two values, off or on, typically represented by "0" or "1." Digital signals require less power but (typically) more bandwidth than analog, and copies of digital signals can be made exactly like the original.

**digital subscriber line (DSL)** - A data communications technology that transmits information over the copper wires that make up the local loop of the public switched telephone network (See local loop).) It bypasses the circuit-switched lines that make up that network and yields much faster data transmission rates than analog modem technologies

**digital subscriber line access multiplexer (DSLAM)** - A device found in telephone company central offices that takes a number of DSL subscriber lines and concentrates these onto a single ATM line.

**direct broadcast satellite (DBS)** - A broadcast technology that uses satellites orbiting the Earth to broadcast television or data signals to an 18" dish antenna.

**discrete multi-tone modulation (DMT)** - A method of transmitting data on copper phone wires that divides the available frequency range into 256 sub-channels or tones, and which is used for some types of DSL.

**discrete wavelet multitone (DWMT)** - A variation of DMT modulation that improves performance by using wavelets rather than tones to provide additional isolation of sub-channels.

**DMT** - See discrete multi-tone modulation.

**DNS** - See domain name system. domain name system (DNS) - The protocol used for assigning text addresses (such as www.2wire.com) for specific computers and computer accounts on the Internet.

**DSLAM** - See digital subscriber line access multiplexer.

**DWMT** - See discrete wavelet multitone.


**F**

**fiber-to-the-cabinet (FTTCab)** - network architecture where an optical fiber connects the telephone switch to a street-side cabinet where the signal is converted to feed the subscriber over a twisted copper pair.

**fiber-to-the-curb (FTTC)** - The deployment of fiber optic cable from a central office to a platform serving numerous homes. The home is linked to this platform with coaxial cable or twisted pair (copper wire). Each fiber carries signals for more than one residence, lowering the cost of installing the network versus fiber to the home.

**fiber-to-the-home (FTTH)** - The deployment of fiber optic cable from a central office to an individual home. This is the most expensive broadband network design, with every home needing a separate fiber optic cable to link it with the central office.

**frame relay** - A high-speed packet switching protocol used in wide area networks (WANs), often to connect local area networks (LANs) to each other, with a maximum bandwidth of 44.725 megabits per second.

**frequency** - The number of oscillations in an alternating current that occur within one second, measured in Hertz (Hz).

**frequency division multiplexing (FDM)** - The transmission of multiple signals simultaneously over a single transmission path by dividing the available bandwidth into multiple channels that each cover a different range of frequencies.

**FTTC** - See fiber-to-the-curb.

**FTTH** - See fiber-to-the-home.

**G**

**G.lite [pronounced "G-dot-light"]** - A kind of asymmetric DSL technology, based on DMT modulation, that offers up to 1.5 megabits per second downstream bandwidth, 384 Kilobits per second upstream, does not usually require a splitter and is easier to install than other types of DSL. "G.lite" is a nickname for the standard officially known as G.992.2. (See International Telecommunications Union.)

**G992.2** - See G.lite.

**general switched telephone network (GSTN)** - See public switched telephone network.

**gigabyte** - 1,000,000,000 bytes, or 1,000 megabytes (see Byte).

**GSTN** - See general switched telephone network.

**GUI** - See graphical user interface.

**H**

**HDSL** - See high bitrate digital subscriber line.

**Hertz** - See frequency.

**hybrid fiber/coax (HFC)** - A type of network that includes coaxial cables to distribute signals to a group of individual locations (typically 500 or more), and a fiber optic backbone to connect these groups.

**high bitrate digital subscriber line (HDSL)** - A symmetric DSL technology that provides a maximum bandwidth of 1.5 megabits per second in each direction over two phone lines, or 2 Megabits per second over three phone lines.

**high bitrate digital subscriber line II (HDSL II)** - A descendant of HDSL which offers the same performance over a single phone line.

**Hz** - See frequency.

**I**

**IDSL** - See ISDN digital subscriber line.

**IEEE** - See Institute of Electrical and Electronics Engineers.

**ILEC** - See incumbent local exchange carrier.

**incumbent local exchange carrier (ILEC)** - A large telephone company that has been providing local telephone service in the United States since the divestiture of the AT&T telephone monopoly in 1982.

**Institute of Electrical and Electronics Engineers (IEEE)** - A membership organization comprised of engineers, scientists and students that sets standards for computers and communications.

**integrated services digital network (ISDN)** - A circuit-switched communication network, closely associated with the public switched telephone network, that allows dial-up digital communication at speeds up to 128 kilobits per second.

**inter-exchange carrier (IXC)** - A long-distance telephone carrier.

**International Organization of Standardization (ISO)** - Develops, coordinates, and prom-ulgates international standards that facilitate world trade.

**International Telecommunication Union (ITU)** - A United Nations organization that coordinates use of the electromagnetic spectrum and creation of technical standards for telecommunication and radio communication equipment.

**International Telecommunication Union/Telecommunication Standardization Sector (ITU-T)** - The branch of the ITU that is responsible for telecommunication standardization.

**Internet protocol (IP)** - The standard signaling method used for all communication over the Internet

**Internet service provider (ISP)** - An organization offering and providing Internet access to the public using computer servers connected directly to the Internet.

**IP** - See Internet protocol

**ISDN** - See integrated services digital network.

**ISDN digital subscriber line (IDSL)** - A type of DSL that uses ISDN transmission technology to deliver data at 128kbps into an IDSL "modem bank" connected to a router.

**ISO** - See International Organization of Standardization.

**ISP** - See Internet service provider.

**ITU** - See International Telecommunication Union.

**ITU-T** - See International Telecommunication Union/Telecommunication Standardization Sector.

**IXC** - See Inter-exchange carrier.

**J**

**Joint Photographic Experts Group (JPEG)** - A committee formed by the International Organization of Standardization to set standards for digital compression of still images. Also refers to the digital compression standard for still images created by this group.

**JPEG** - See Joint Photographic Experts Group.

**K**

**Kilobit** - One thousand bits (see bit).

**Kilobyte** - One thousand bytes (see byte).

**L**

**last mile** - See local loop.

**local area network (LAN)** - A network connecting a number of computers to each other or to a central server so that the computers can share programs and files.

**LAN** - See local area network.

**Local exchange carrier (LEC)** - A local telephone company. LECs provide telephone service for phone calls originating and terminating within a single LATA.

**local loop** - The copper lines between a customer's premises and a telephone company's central office (See central office).

**M**

**Mb/s** - Megabits per second.
**Megabit** - One million bits.
**Megabyte** - 1,000,000 bytes, or 1,000 kilobytes (see Byte).
**millions of instructions per second (MIPS)** - This is a common measure of the speed of a computer processor.
**modem (MOdulator-DEModulator)** - A device that converts digital data into analog signals and vice-versa for transmission over a telephone line.
**Multicast** - The transmission of information over the Internet to two or more users at the same time.
**multiplexing** - Transmitting multiple signals over a single communications line or computer channel. The two common multiplexing techniques are frequency division multiplexing, which separates signals by modulating the data onto different carrier frequencies, and time division multiplexing, which separates signals by interleaving bits one after the other.

**N**

**narrowband** - A designation of bandwidth less than 56 kilobits per second.
**Narrowband ISDN** - same as ISDN.

**O**

**packet-switched network** - A network that allows a message to be broken into small "packets" of data that are sent separately by a source to the destination. The packets may travel different paths and arrive at different times, with the destination sites reassembling them into the original message. Packet switching is used in most computer networks because it allows a very large amount of information to be transmitted through a limited bandwidth.

**P**

**passive optical network (PON)** - a fiber-based transmission network containing no active electronics.
**peripheral** - An external device that increases the capabilities of a communication system.
**plain old telephone service (POTS)** - An acronym identifying the traditional function of a telephone network to allow voice communication between two people across a distance. In most contexts, POTS is synonymous with the public switched telephone network (PSTN).
**point of presence (POP)** - The physical point of connection between a data network and a telephone network.
**PON** - See passive optical network.
**POP** - See point of presence.
**POTS** - See plain old telephone service.
**POTS splitter** - A device that uses filters to separate voice from data signals when they are to be carried on the same phone line, required for several types of DSL service.
**PRI-ISDN** - See primary-rate ISDN.
**primary-rate ISDN (PRI-ISDN)** - The primary rate ISDN interface provides 23 64 Kb/s channels (called B channels) to carry voice or data and one 16 Kb/s signaling channel (the D channel) for call information.

**R**

**radio frequency (RF)** - Electromagnetic carrier waves upon which audio, video, or data signals can be superimposed for transmission.
**RADSL** - See rate-adaptive asymmetric digital subscriber line.
**rate-adaptive digital subscriber line (RADSL)** - A variation of DSL that uses carrierless amplitude phase modulation, divides the available frequencies into discrete sub-channels and also maximizes performance by adjusting the transmission to the quality of the phone line while in use.
**RF** - See radio frequency.
**Router** - The central switching device in a packet-switched computer network that directs and controls the flow of data through the network.

**S**

**sdsl - Symmetric Digital Subscriber Line** - This technology provides the same bandwidth in both directions, upstream and downstream. That means whether you're uploading or downloading information, you have the same high-quality performance. SDSL provides transmission speeds within a T1/E1 range, of up to 1.5 Mbps at a maximum range of 12,000 - 18,000 feet from a central office, over a single-pair copper wire. This option is ideal for small and medium sized businesses that have an equal need to download and upload data over the Internet.

**T**

**T1.413** - The American National Standards Institute (ANSI) standard for asymmetric digital subscriber line using discrete multitone modulation, which the G.dmt standard is based on.
**T-1** - A dedicated digital communication link provided by a telephone company that offers 1.544 megabits per second of bandwidth, commonly used for carrying traffic to and from private business networks and Internet service providers.
**T-3** - A dedicated digital communication link provided by a telephone company that offers 44.75 megabits per second of bandwidth, commonly used for carrying traffic to and from private business networks and Internet service providers.
**TCP/IP** - See transmission control protocol/Internet protocol.
**telecommuting** - The practice of using telecommunication technologies to facilitate work at a site away from the traditional office location and environment. teleconference - Interactive, electronic communication among three or more people at two or more sites. Includes audio-only, audio and graphics, and video-conferencing.
**terabyte** - 1,000,000,000,000 bytes, or 1,000 gigabytes (see Byte).
**time division multiplexing (TDM)** - A digital data transmission method that takes signals from multiple sources, divides them into pieces which are then placed periodically into time slots, transmits them down a single path and reassembles the time slots back into multiple signals on the remote end of the transmission.
**transmission control protocol/Internet protocol (TCP/IP)** - A method of packet-switched data transmission used on the Internet. The protocol specifies the manner in which a signal is divided into parts, as well as the manner in which "address" information is added to each packet to ensure that it reaches its destination and can be reassembled into the original message.
**twisted pair** - The set of two copper wires used to connect a telephone customer with a switching office, loosely wrapped around each other to minimize interference from other twisted pairs in the same bundle. Synonymous with 2-wire line.

**U**

**UAWG** - See Universal ADSL Working Group.
**Uniform Resource Locator (URL)** - A text-based address used to identify specific resources on the Internet, such as web pages. URLs are arranged in a hierarchical form that specifies the name of the server on which a resource is located (such as www.2wire.com) and the name of the file on that server (www.2wire.com/index.html).
**Universal ADSL Working Group (UAWG)** - An organization composed of leading personal computer industry, networking and telecommunications companies with the goal of creating an interoperable, consumer-friendly ADSL standard titled the G.992.2 standard, and commonly referred to as the G.lite standard.

**V**

**variable bit rate (VBR)** - A data transmission that can be represented by an irregular grouping of bits or cell payloads followed by unused bits or cell payloads.

**W**

**WAN** - See wide area network.
**wide area network (WAN)** - A network that interconnects geographically-distributed computers or LANs.

**X**

**X.25 data protocol** - A packet switching standard developed in the mid-1970s for transmission of data over twisted pair copper wire.
**xDSL** - See DSL.

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