

DSL White Paper

Executive Summary

Most mid-level home and small office computers are capable of more than 1GHz processing and are only seriously hampered when they log into a dial-up Internet connection. A Digital Subscriber Line (DSL) is a type of broadband connection that takes advantage of the existing telephone cables to enable high-speed data transmissions to and from a customer's premises. There are a number of different types of DSL, which have been designed to suit a range of customer requirements.

This white paper contains the following sections:

A. What is DSL?

Provides an overview of the technology and a description of the main types of DSL in use today.

B. Focus on ADSL

Focuses on Asymmetric DSL, providing details on how this technology works.

C. How does Allied Telesis Support DSL?

Outlines how Allied Telesis provides DSL support for their customers.

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A. What is DSL?

Introduction

That familiar eeeeeeh ... du, du, du, du du screech that your dial-up modem makes when you connect to the Internet is rapidly becoming a sound of the past, not because of the annoying screech but because of the demand for greater bandwidth and faster Internet connections.

Most mid-level home and small office computers are capable of more than 1GHz processing and are only seriously hampered when they log into a dial-up Internet connection. The analogue telephone frequency range has a limited bandwidth, so if data communication equipment is limited to only use that range, then only small amounts of information can be sent and received over the phone line at one time. In the same way that more lanes on a highway enable more cars to travel on it at one time, broadband telecommunication enables a wide band of frequencies or channels to transmit information concurrently on a wire, which means more information can be sent in a given amount of time.

There are a number of broadband access platforms, but the one with the most rapid uptake is DSL. Other broadband platforms include ISDN, Leased Lines, terrestrial broadcast, cable and cable modem, satellite, fibre optic, fixed wireless access (FWA), mobile wireless and powerlines. The first quarter of 2004 saw 9.5 million new DSL lines worldwide, which is almost double the DSL uptake for the same period in 2003, taking the total number of DSL subscribers worldwide to more than 73 million¹. In comparison, worldwide cable modem subscriptions will only get near the current DSL figures in 2007 when 68 million subscribers are expected².

China has the largest DSL population in the world with almost 14 million subscribers in the first quarter of 2004, followed by Japan and the USA. In global terms, the Asia Pacific region has 29.34 percent of all DSL subscriptions, followed by the European Union with 28.18 percent, then South and Southeast Asia with 20 percent and North America with 17.60 percent³.

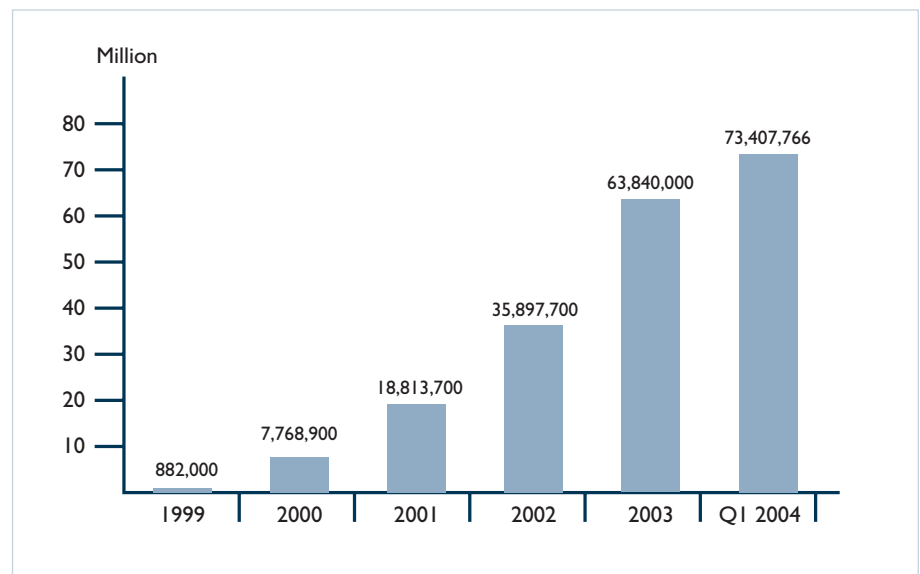


Figure 1: Growth in DSL Subscribers 1991 – Q1 2004 (Source: Point Topic)

¹ DSL Forum http://www.dslforum.org/pressroom.htm?page=PressRoom/presentation_6.9.04.pdf

² According to In-Stat/MDR, cited in 'DSL has record growth spurt' by Robyn Greenspan <http://www.clickz.com/stats/markets/broadband/article.php/3381201>

³ According to the Probe Group cited in 'DSL has record growth spurt' by Robyn Greenspan <http://www.clickz.com/stats/markets/broadband/article.php/3381201>

What is DSL?

Digital Subscriber Line (DSL) is a broadband connection that uses the existing telephone line. DSL provides high-speed data transmissions over the twisted copper wire, the so-called “last-mile” or “local loop”, that connects a customer’s home or office to their local telephone company Central Offices (COs). There are a number of different types of DSL and they are referred to collectively as xDSL.

How does DSL work?

The traditional phone service (also known as the Plain Old Telephone Service or POTS) was created to exchange voice information using an analogue signal. Computers, however, use digital signals to communicate, so in order for this signal to travel over the telephone network, a modem is needed to convert the digital data to analogue and back again.

The telephone analogue frequency uses only a small proportion of the bandwidth on a line (under 4kHz). The maximum amount of data that conventional dial-up modems can transmit through a POTS system is about 56Kbps. Using this method to send data, the transmission through the telephone company is a bandwidth bottleneck.

Typical telephone cabling is capable of supporting a greater range of frequencies (around 1MHz). With DSL modems, the digital signal is not limited to 4kHz of voice frequencies, as it does not need to travel through the telephone switching system. DSL modems enable up to 1MHz of bandwidth to be used for transmitting digital (data) alongside analogue (voice) signals on the same wire by separating the signals, thereby preventing the signals from interfering with each other. Figure 2 shows how the analogue and digital frequencies are split.

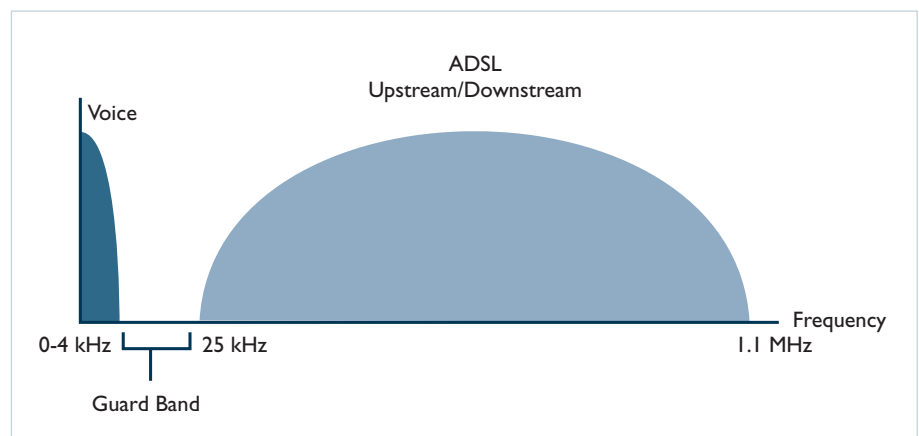


Figure 2: Splitting the Frequencies

DSL modems establish a connection from one end of a copper wire to the other end of that copper wire, as shown in Figure 3. Although DSL stands for Digital Subscriber Line, DSL actually signifies the pair of modems at each end of a line and not the line at all. So when customers buy a DSL connection they actually buy the modems or the use of the modems at each end of a line. In contrast, dial-up modems establish a data stream between two arbitrary points using the entire telephone system—from the sender's local loop, through the telephone switching system and then to the receiver's local loop. These dial-up modem connections can span continents, with one end being thousands of kilometres from the other.

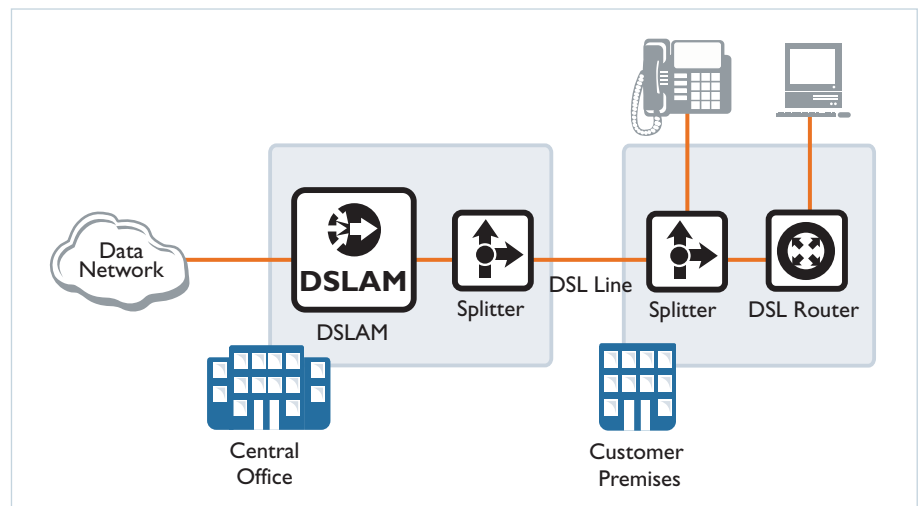


Figure 3: DSL Connection Setup

What are the benefits of DSL?

DSL is a more cost effective option than many other broadband connections, such as leased lines, terrestrial broadcast, cable and cable modem, satellite and fibre optic connections, because it is able to take advantage of the existing telephone infrastructure for both voice and data traffic. Only the user's modem and the telecommunications equipment needs to be upgraded when moving to a DSL connection because it utilises the existing cable infrastructure.

DSL is always on, always fast and always reliable. DSL connections are point-to-point dedicated circuits that are always connected, so there is no time lost dialling up.

What are the variants of DSL?

There are numerous different DSL technologies. The range of DSL types reflects the numerous different applications requiring different data rates. Generally speaking, the variations of DSL technology have been implemented to meet the needs of different users, such as home users, small to medium sized businesses, schools and colleges. See table 1 on page 9 for a comparison of the data rates and their applications.

The DSL variants can be broadly divided into the three following groups:

Symmetric DSL

Symmetric DSL transmits data at the same rate upstream and downstream. It includes the following DSL types:-

- High data rate Digital Subscriber Line (HDSL)
- Symmetric Digital Subscriber Line (SDSL)
- Symmetric High bit rate Digital Subscriber Line (SHDSL)

Asymmetric DSL

Asymmetric DSL transmits data at a faster rate downstream than upstream. It includes the following DSL types:

- Asymmetric Digital Subscriber Line (ADSL)
- Asymmetric Digital Subscriber Line Lite (ADSL lite)
- Asymmetric Digital Subscriber Line 2 (ADSL 2)
- Asymmetric Digital Subscriber Line 2+ (ADSL 2+)
- Asymmetric Digital Subscriber Line 2++ (ADSL 2++ or ADSL4)

Symmetric and Asymmetric DSL

Symmetric and Asymmetric DSL can transmit data both symmetrically and asymmetrically. It includes the following DSL type:

- Very high bit rate Digital Subscriber Line (VDSL)

Symmetrical DSL

High data rate Digital Subscriber Line (HDSL)

HDSL is the earliest version of symmetric DSL that was created as an alternative to T1 and E1 services. T1 is the most commonly used digital line used in the United States, Canada and Japan, and transmits data at speeds up to 1.544Mbps. E1 is the European equivalent and transmits data at speeds up to 2.048Mbps. HDSL is a better way of transmitting T1 or E1 over twisted pair copper lines. HDSL splits a 1.544Mbps signal into two twisted wire pairs which run at 784Kbps, allowing the service to run on longer loops without repeaters, for example, 3.7km (12,000ft.) on .5mm (24 gauge) wire. HDSL uses more advanced modulation techniques than T1 and E1. HDSL does not allow standard telephone service over the same line.

Single line Digital Subscriber Line (SDSL)

SDSL is a single line version of HDSL, supporting POTS and SDSL simultaneously with equal data rates (up to 2.3Mbps) for the upstream and downstream channels. SDSL is ideally suited to individual subscriber premises which are often only equipped with a single telephone line. SDSL has a maximum reach of approximately 3km (10,000ft).

Symmetric High bit rate Digital Subscriber Line (SHDSL)

SHDSL, also known as G.SHDSL, is the first standardised multi-rate DSL, providing transmission speeds of up to 2.3Mbps across a single pair and up to 4.6Mbps over two pairs. SHDSL has a better loop reach than older versions of DSL and has less cross talk interference. SHDSL is able to utilise the existing copper base to achieve increased data rates, longer reach and less noise. SHDSL is better suited to business applications requiring higher-speed bandwidth in both directions.

Asymmetric DSL

Asymmetric Digital Subscriber Line (ADSL)

ADSL is the transmission of integrated voice and data services with higher data rates downstream (to the user) than upstream. ADSL can reach speeds of up to 10Mbps downstream and 1Mbps upstream. ADSL enables customers to use both their normal telephone service and high-speed digital transmissions on an existing telephone line.

ADSL is ideally suited to home and small office users who require fast download rates for video on demand, home shopping, Internet access, remote LAN access, multimedia access and other specialised PC services.

G.lite or Asymmetric Digital Subscriber Line Lite (ADSL lite)

G.lite, also known as ADSL lite, splitterless ADSL and Universal ADSL, was specifically developed for the plug-and-play market. G.lite is essentially a slower ADSL that does not require signals to be split at the user's end, only at the telephone company. A medium bandwidth version of ADSL delivers up to 1.5Mbps downstream and 384Kbps upstream.

Asymmetric Digital Subscriber Line 2 (ADSL2)

ADSL2 has improved performance and interoperability over ADSL. ADSL2 provides support for new applications, services and deployment scenarios, and can achieve higher data rates of approximately 12Mbps downstream, depending on loop length and other factors.

ADSL2 increases the reach of ADSL by about 0.2km (600ft.). ADSL2 also provides greater noise immunity, better diagnostics, lower cross talk, and allows bonding - the ability to use multiple copper pairs to increase the bandwidth or size of the pipes. For example, with four bonded pairs it is possible to obtain 40Mbps, which is particularly useful for broadcast video.

Asymmetric Digital Subscriber Line 2+ (ADSL2+)

ADSL2+ further enhances ADSL2 by increasing the downstream rate to 20Mbps on phone lines as long as 1.5km (5,000ft.). The ADSL2+ standard doubles the maximum frequency used for downstream data transmission from 1.1MHz to 2.2MHz. ADSL2+ solutions most commonly interoperate with ADSL, ADSL2 and ADSL2+ chipsets.

Asymmetric Digital Subscriber Line 2++ (ADSL2++ or ADSL4)

The current proposal for ADSL2++ (also known as ADSL4) increases the downstream data rate to 52Mbps by extending the maximum frequency used for downstream data transmission to 3.75MHz.

Both Symmetric and Asymmetric DSL

Very high bit rate Digital Subscriber Line (VDSL)

VDSL provides the highest data rates of the DSL technologies, supporting asymmetric transmission speeds of up to 52Mbps over short distances. VDSL can also be configured for symmetric transmissions to provide 10Mbps full duplex Ethernet services for distances up to 1.3km (4,260ft).

VDSL is a robust, economical and flexible broadband access technology, incorporating high bit rate capabilities, low cost multiple megabit data services, efficient use of POTS infrastructure and compatibility with Ethernet. VDSL is particularly useful for supplying high bandwidth services for large buildings such as hotels, office towers and apartments without the need for new infrastructure. VDSL is also ideal for university campuses or business parks, where there is a short distance to a neighbourhood cabinet that is linked by fibre optic to the exchange. VDSL is able to handle a number of high bandwidth applications, such as VPNs, file downloading/uploading, video on demand, high definition television, broadcast television, tele-medicine, tele-conferencing, and surveillance systems.

Comparison of DSL Types

| DSL Type | Maximum Downstream Data Rate | Maximum Upstream Data Rate | Maximum Wire Length (Approx.) | Customer Applications |
|--|--|----------------------------------|---|--|
| Symmetric | | | | |
| HDSL High data rate Digital Subscriber Line | 1.544Mbps (T1) 2.048 Mbps (E1) | 1.544Mbps (T1) 2.048Mbps (E1) | 3.7km (12,000ft.) with two lines for T1 and three lines for E1 | HDSL is for data only. It does not allow telephone connection over the same line. |
| SDSL Symmetric Digital Subscriber Line | 2.3Mbps | 2.3Mbps | 3km (10,000ft.) | Individual subscriber premises with a single telephone line |
| SHDSL Symmetric High bit rate Digital Subscriber Line | 2.3Mbps (Single wire pair) | 2.3Mbps (Single wire pair) | 3km (9,800ft.) at 2.3Mbps | Business applications requiring greater bandwidth in both directions. |
| | 4.6Mbps (Two wire pairs) | 4.6Mbps (Two wire pairs) | 5km (16,400ft.) at 2.3Mbps | |
| Asymmetric | | | | |
| ADSL Asymmetric Digital Subscriber Line | Up to 10Mbps | Up to 1Mbps | 5.5km (18,000ft.) | Home and small office users who require faster download rates for video on demand, home shopping, Internet access, remote LAN access, multimedia access and other specialised PC services. |
| ADSL lite Asymmetric Digital Subscriber Line Lite | Up to 1.5Mbps | Up to 384kbps | 5.5km (18,000ft.) | Residential and small office users wanting a simple plug-and-play setup. |
| ADSL 2 Asymmetric Digital Subscriber Line Two | 12Mbps | 1Mbps | 5.5km (18,000ft.) | ADSL2 addresses the growing demand for more bandwidth to support services such as video. |
| ADSL 2+ Asymmetric Digital Subscriber Line Two Plus | 20Mbps downstream on short distances | 1Mbps | 5.5km (18,000ft.) | ADSL2+ enables even greater downstream data rates for subscribers who are relatively near the telephone exchange. |
| ADSL 2++ Asymmetric Digital Subscriber Line Two Plus Plus (or ADSL4) | 52Mbps downstream on short distances | | | ADSL2++ proposes to further increase downstream data rates for customers who are relatively near the telephone exchange. |
| Symmetric and Asymmetric | | | | |
| VDSL Very high bit rate Digital Subscriber Line | Symmetric - 10Mbps | 10Mbps | 1.3km (4,200ft.) | Campus environments, such as universities or business parks, where there is a short distance to a neighbourhood cabinet that is linked by fibre optic to the exchange. VDSL handles a number of high bandwidth applications, such as VPNs, file downloading/ uploading, video on demand, high definition television, broadcast television, tele-medicine, tele-conferencing, and surveillance systems. |
| | Asymmetric - up to 52Mbps over short distances | 1.5Mbps | 0.3km (1,000ft.) | |

B. Focus on ADSL

Introduction

Asymmetric Digital Subscriber Line (ADSL), an important variant of the DSL family, has become very popular. With ADSL, most of the data bandwidth is devoted to sending data downstream towards the user and a smaller proportion of the bandwidth is available for sending data upstream towards the service provider. This scenario suits Internet browsing applications, which typically involve much more downstream than upstream dataflow.

How is an ADSL network setup?

When digital data is sent from a customer's premises, it travels from their computer through a DSL modem and a splitter. When analogue voice signals are sent from a customer's telephone they are also sent through the splitter, which combines the analogue voice and digital data signals, enabling them to be sent over the same line.

At the other end of the line, the local loop goes into a splitter at the local phone company's COs, which splits the digital data frequencies from the analogue voice frequencies. The voice frequencies are sent to the local telephone exchange and the digital data is sent to a Digital Subscriber Line Access Multiplexor (DSLAM) before being sent on to the Internet Service Provider (ISP). The digital data never enters the standard telephone switching system.

Voice and data frequencies going in the opposite direction—to the customer's premises—follow the reverse route from the ISP through a DSLAM, then a splitter at the CO, and are then sent over the copper wires to the customer's site before being split again.

The DSLAM is the equipment that really allows DSL to happen. The DSLAM handles the high-speed digital data stream coming from numerous customers and aggregates it onto a single high-capacity connection (ATM or Gigabit Ethernet line) to the Internet Service Provider and vice versa. DSLAMs are generally flexible and can support a number of different DSL connections as well as different protocol and modulation technologies in the same type of DSL. Figure 4 shows how an ADSL network is setup.

IP and ATM DSLAMs

There are two main types of DSLAM—IP DSLAM and ATM DSLAM. When ADSL services first began, ATM was the main high-speed data backbone transport used in Telecommunications networks. So DSLAMs with an ATM uplink port (ATM DSLAMs) were developed to enable the ADSL link to connect quite seamlessly into the whole ATM network. The 'last mile' ATM link over the ADSL line was then just an extended finger of a telecommunications company's ATM network.

Recently, Ethernet has taken quite a step up in bandwidth capabilities (from up to one Gigabit, to 10 Gigabit) and is becoming a cheaper and more popular choice for the transport protocol in Metro Area Networks. In installations where subscribers are using DSL to access a Metro Area Network, it makes sense for the DSLAMs to have Ethernet uplink ports. DSLAMs with Ethernet uplink ports are known as IP DSLAMs. The market is rapidly moving towards IP DSLAMs because they are cheaper to implement, scale better and are easier to manage than ATM DSLAMs.

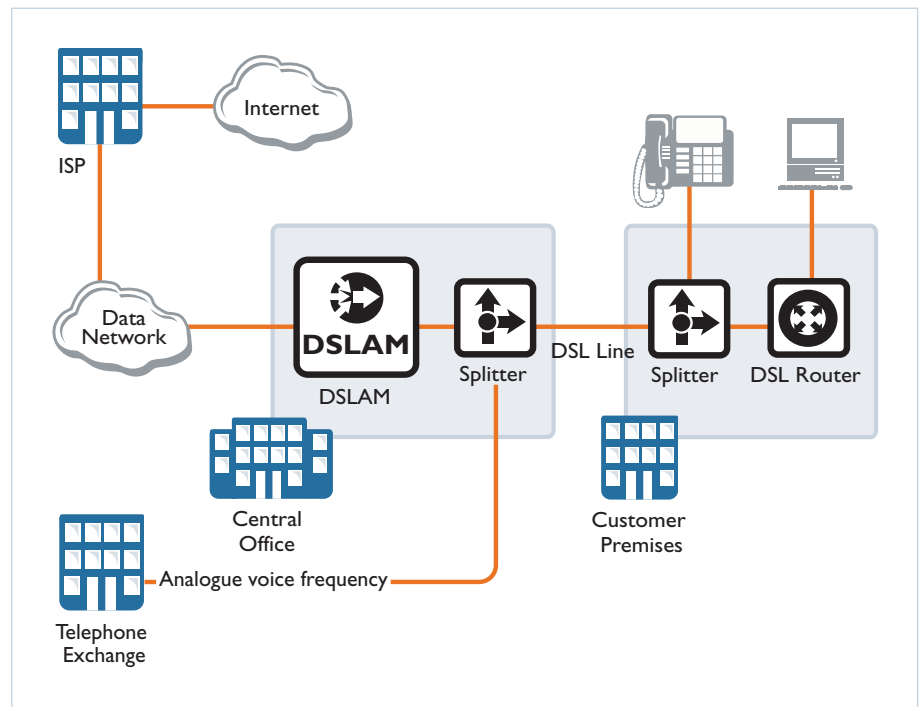


Figure 4: ADSL Network Setup

How does DSL get more bandwidth from the same old copper wires?

The DSL transmission technology exploits the fact that all telephone signals are below 4kHz in frequency and makes use of the rest of the 1MHz that a typical copper pair line can support. ADSL modems use specialised modulation technology to divide the available bandwidth on a copper pair line and create multiple channels for sending and receiving signals.

Modulation technologies

Modulation is the overlaying of information (or the signal) onto an electronic or optical carrier waveform. There are two competing and incompatible standards for modulating the ADSL signal, known as Discrete Multi-Tone (DMT) and Carrierless Amplitude Phase (CAP). CAP was the original technology used for DSL deployments, but the most widely used method now is DMT.

Carrierless Amplitude Phase (CAP)

Carrierless Amplitude Phase (CAP) is an encoding method that divides the signals into two distinct bands:

- The upstream data channel (to the service provider), which is carried in the band between 25 and 160kHz.
- The downstream data channel (to the user), which is carried in the band that starts at 200kHz and continues to a variable end point, depending on a number of factors, such as line length and line noise, but the maximum is about 1.1MHz.

These channels are widely separated in order to minimise the possibility of interference between the channels.

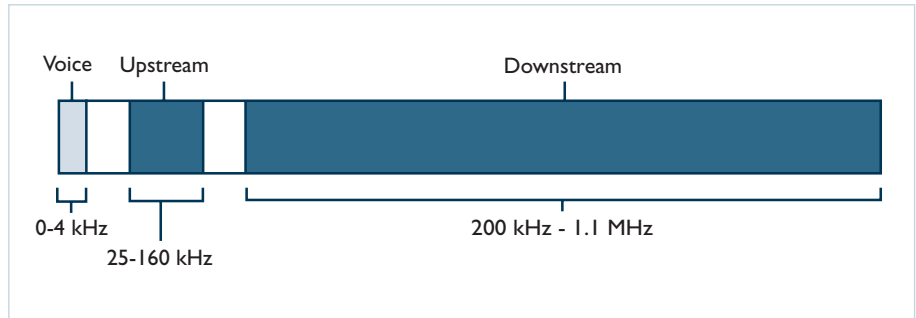


Figure 5: Carrierless Amplitude Phase (CAP)

Discrete Multi-tone (DMT)

Discrete Multi-Tone (DMT), the most widely used modulation method, separates the DSL signal so that the usable frequency range is separated into 256 channels of 4.3125kHz each. DMT has 224 downstream frequency bins (or carriers) and 32 upstream frequency bins. Up to 15 bits per signal can be encoded on each frequency bin on a good quality line.

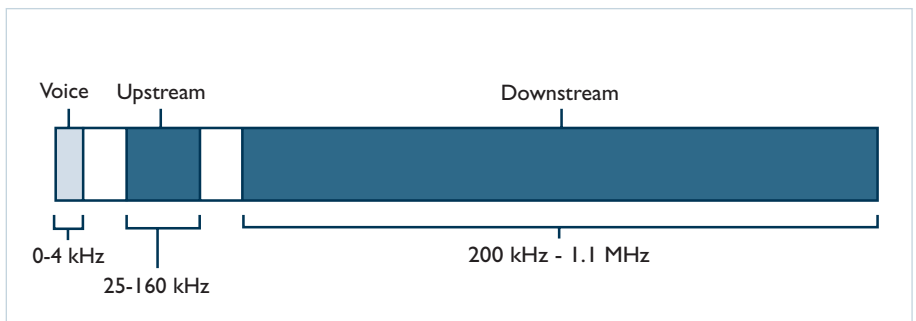


Figure 6: Discrete Multi-Tone (DMT)

Each of the 256 channels is monitored separately to ensure the data travelling along it is not impaired. DMT constantly shifts signals between different channels to ensure that the best channels are used for transmission and reception. DMT can take advantage of all usable tones in the spectrum and works around areas where interference is present. Some of the lower channels can be used as bi-directional channels for both upstream and downstream information.

DMT is more complex than CAP because it monitors and sorts out the information on the bi-directional channels and maintains the quality on all of the 256 channels. DMT also provides more flexibility on lines of differing quality than CAP.

Rate adaptive DSL

The ADSL implementations in use today are sometimes referred to as rate adaptive DSL because the data transmission rate can be adapted to the line conditions. Rate adaptive DSL provides higher capacities for subscribers who are closer to the local telephone exchange and lower rates for subscribers who are further away. Although CAP is rate adaptive, DMT has significantly higher rate adaptability.

The DMT frequency bands can be used in two different ways, which are referred to as Frequency Division Multiplexing (FDM) and Echo Cancellation.

Frequency Division Multiplexing (FDM)

With FDM, the low-speed upstream channel is quite separate from the high-speed downstream channel. In order to prevent interference between the frequency bands, a space, known as the guardband, is required between the upstream and downstream frequencies. Most ADSL modems today use FDM.

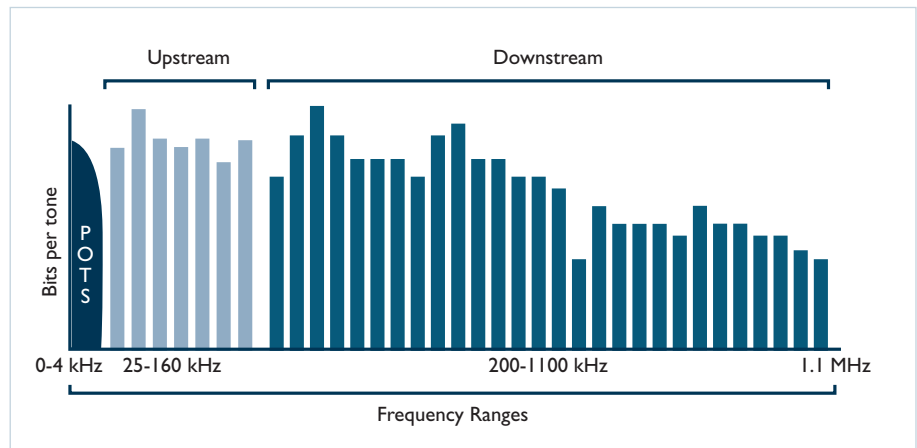


Figure 7: Frequency Division Multiplexing

Echo Cancellation

With Echo Cancellation the downstream channel overlaps the upstream channel, so simultaneous upstream and downstream signals are sent on the lower frequencies. An echo on the upstream signal can cause corruption on the downstream signal. Echo cancellation is used to obtain a clear signal in the event that both streams send data simultaneously.

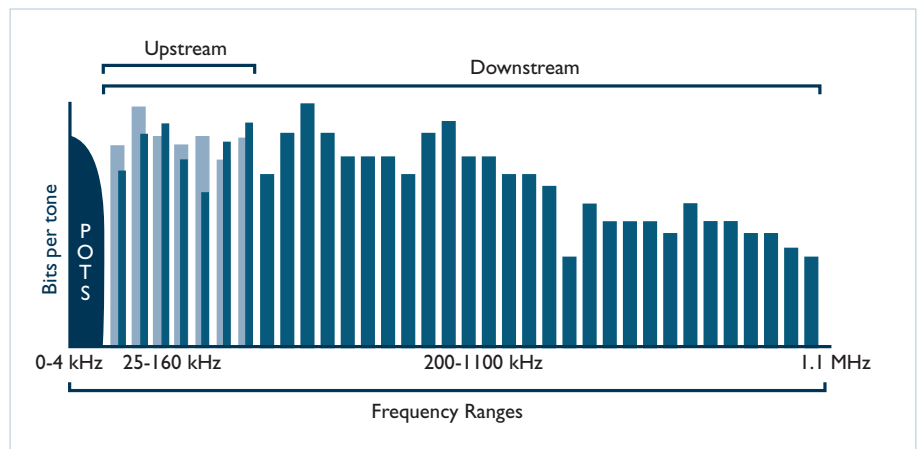


Figure 8: Echo Cancellation

Asynchronous Transfer Mode (ATM)

The ADSL standards mentioned above define the data modulation and byte framing used for transmission on the copper pair. However, they do not define any mechanism for dividing bytes into packets so they can navigate through a network. A higher layer protocol is needed for this. The universal choice of Layer-2 protocol for use on ADSL lines is Asynchronous Transfer Mode (ATM). ATM allows multiple diverse services with different service requirements to be carried over a single network efficiently and effectively. It has been developed specifically for this purpose.

ATM transfers data in small packets, known as cells, of a fixed size of 53 bytes. The 53 bytes in each ATM cell are made up of 48 bytes of payload and a 5-byte header. The header contains channel and path information to direct the cell to its destination, while the other 48 bytes contain the data. The ATM cell is small compared to the size other technologies use. This allows ATM equipment to transmit video, audio, and computer data over the same network, and assure that data streams can be efficiently interleaved with each other. Networks can effectively re-use quiet periods in one application to service a busy period in another. This treatment of the traffic load is known as statistical multiplexing and is one of the key advantages of ATM.

Virtual Circuits and Virtual Paths

ATM is a connection-oriented protocol, which means that packets are sent through a network directly from their originating device to a destination device on a pre-established connection. This connection is known as a virtual circuit and all the switches along the end-to-end path know about each circuit and where to send the packets next. ATM also uses virtual paths, which are a convenient aggregation of multiple virtual circuits all going in the same direction. In the core of the network, packets can be forwarded on the basis of their path identifier, thereby enabling a quicker destination lookup.

Because ATM is a connection-oriented protocol, the demands on the network can be easily monitored for expected volumes and destinations. ATM also prevents applications from using the network when additional traffic will adversely affect the performance of the existing applications. Because the connections are pre-established, packets only need to be labelled with the locally significant identification, reducing the size of the header information in each packet.

Traffic Classes

ATM networks recognise a small number of types of service or traffic classes that are designed to meet a variety of application requirements. Within each type of service there are a range of parameters that can be specified to further define the service. When a connection request is made, the ATM network either agrees to provide a sufficiently high quality connection to meet the needs of the application, or rejects the request. If the application exceeds the parameters it agreed to on connection, the network may provide a degraded service.

The three most commonly implemented types of ATM service are:

Constant Bit Rate (CBR), which specifies a fixed bandwidth with minimum latency and jitter so that data is sent in a steady stream. CBR is analogous to a leased line and is suitable for high-quality voice calls and near real time applications where the bandwidth requirements are fixed and known.

Variable Bit Rate (VBR), which provides an average bandwidth, but allows the data to be sent in bursts at higher rates up to a maximum size. VBR is suited to voice and video conferencing applications, which require reduced latency and jitter.

Unspecified Bit Rate (UBR), which does not guarantee any throughput level. UBR is a best effort service and is used for applications that can tolerate delays, such as file transfers. Most xDSL services use UBR.

ATM adaption layer

The ATM Adaptation Layer (AAL) converts information from the upper layers into ATM cells. The data packets that are sent over the physical medium in a network are IP packets (encapsulated in Point-to-Point-Protocol or Ethernet) that are variable in size, while ATM cells are a fixed 53-bytes in size, including their header information. To transport IP packets in ATM cells, the packets need to be broken into pieces and reassembled at their destination. Often the length of the IP packets is not an exact multiple of 48 (the payload size of ATM cells), so some buffering is usually required. There have been a few different standards for breaking up and buffering IP packets, but the standard that is used for ATM over ADSL services is AAL5.

AAL5 Encapsulation Methods

RFC 1483 specifies the values to put into the AAL5 header and footer, which vary depending on the protocol that is being transported. RFC 1483 describes two encapsulation methods for carrying different types of network traffic over ATM AAL5—Virtual Channel Multiplexing (VCMux) and LLC/SNAP. These methods have been universally accepted as the methods of encapsulating packets for transportation on an ATM network.

VCMux enables you to create multiple VCs on your ADSL link and send a different protocol down each VC. This way the receiver knows that all the packets arriving on a particular VC belong to a particular protocol.

LLC/SNAP enables different protocols to be sent along one VC. With LLC/SNAP, extra headers are added to the data packets before they are passed into the AAL5 process and broken into ATM cells. The headers include a field that specifies the protocol type of the enclosed data packet. There are two types of LLC/SNAP headers: RFC 1483 Routed and RFC 1483 Bridged.

What happens in the upper layers

There has been no universal agreement reached over the sort of packet on which to perform RFC 1483 encapsulation, so there are now a number of different choices of protocol stack to have above the RFC 1483 Layer:

The most common protocol stack is Point-to-Point Protocol over Ethernet and ATM (PPPoEoA). Figure 9 demonstrates how PPPoEoA enables IP packets to travel over both an Ethernet and an ATM connection.

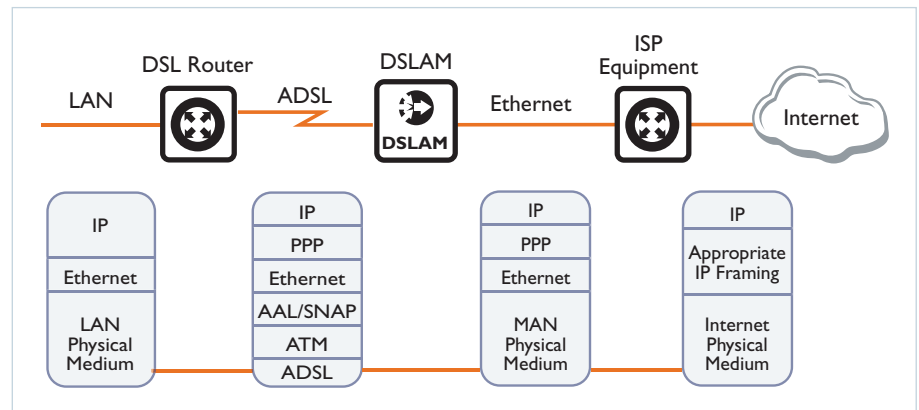


Figure 9: Point-to-Point Protocol over Ethernet over ATM (PPPoEoA)

When travelling from the LAN to an ADSL connection, IP packets encapsulated in Ethernet frames pass through an ADSL router, which attaches a PPP header to the frames. The frames then undergo AAL5 encapsulation to create smaller ATM cells, which are sent over the ADSL connection to a DSLAM at the local phone company office.

The DSLAM in this instance is connected to an Ethernet network, so the ATM cells go through the reverse process described above to reveal the Ethernet frames, which are sent on to the ISP. At the ISP, the Ethernet frames are removed to reveal the IP data, which is then framed according to the network it will continue to travel on.

Other protocol stacks include:

[IPoA](#), which was designed to make IP subnets map directly onto ATM networks in the same way that IP subnets map onto VLANs. So, an ATM address resolution protocol was introduced to enable the IP stack to obtain an "ATM address" for another IP host connected to its local ATM subnet (RFC 2225). The structure required for this kind of network is quite complex, mostly because trying to make a channel oriented transportation method like ATM appear like a broadcast domain is not a very natural fit.

[RFC 1483 Bridged](#), which is where the whole Ethernet packet that arrives at the ADSL router is encapsulated into AAL5, using the 'bridged-data' format defined in RFC 1483, and sent on the ADSL line. The packets are forwarded based on their MAC address, so they are bridged.

[RFC 1483 Routed](#), which uses the same 'bridged-data' format as RFC 1483 Bridged to encapsulate Ethernet packets into AAL5. However, the packets are forwarded based on their IP address, so they are routed.

Dying Gasp

When a modem is about to die, because it has lost power, dying gasp enables it to send a message to the DSLAM letting it know that it is about to go offline. The modem is able to do this by using a large capacitor to retain enough power to send the message before dying completely. This dying gasp message saves Service Providers time by alerting them to what has caused the connection failure.

What is the difference between Annex A and Annex B ADSL?

Annex A ADSL defines how ADSL can share a line with a POTS service.

Annex B ADSL defines how ADSL can share a line with an Integrated Services Digital Network (ISDN) service.

What are the main factors affecting the performance of DSL?

There are a number of factors that can affect DSL performance. The most common factors are attenuation, bridge taps, load coils and cross talk. Other factors affecting performance include return loss, longitudinal balance, noise, split pairs, gauge changes, and interruptions. Environmental factors can also have adverse effects on the transmission lines used for telecommunications.

Attenuation

With all DSL technologies there is a trade off between the data rate and cable distance, so as the distance between the customer's premises and Telephone Company's local office increases the data rate drops. On network cables, the degradation of the digital signal or a loss of amplitude of an electric signal during transmission is known as attenuation. As the line length increases, the downstream frequencies suffer from attenuation, which also increases with higher temperatures. (See Figure 10).

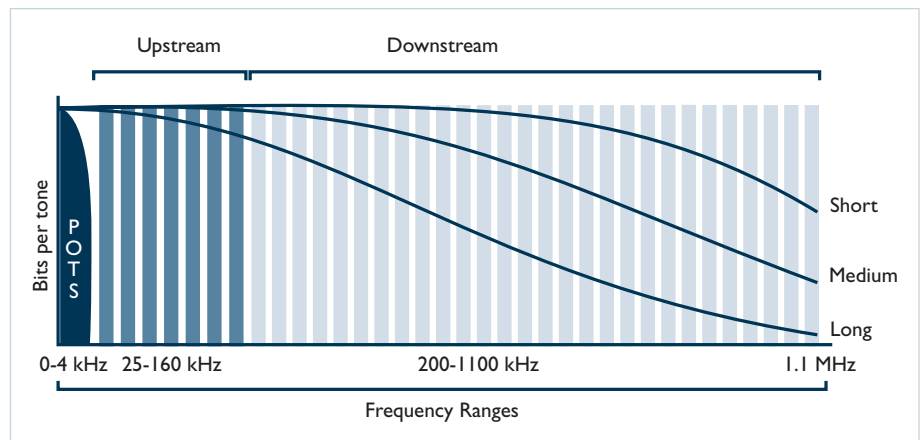


Figure 10: Attenuation on DMT Spectrum

Bridge Taps

A bridge tap is an extra length of wire with an unterminated cable end, which is connected to the local loop. Bridge taps are usually left over when a new subscriber is connected to existing pair of copper wires, and the original subscriber at the end of another pair is disconnected, leaving an open lead at that end of the wire. When the DSL signal is sent across the wire, it reflects through the bridge tap cable pair towards the open lead and then bounces back along the wire. This signal is then mixed with the original signal and can confuse the modem. However, most modems will only listen to the stronger original signal and ignore the weaker, reflected signal. Most cable pairs in the world have bridge taps that should be removed before installing a DSL connection in order to ensure a clear signal.

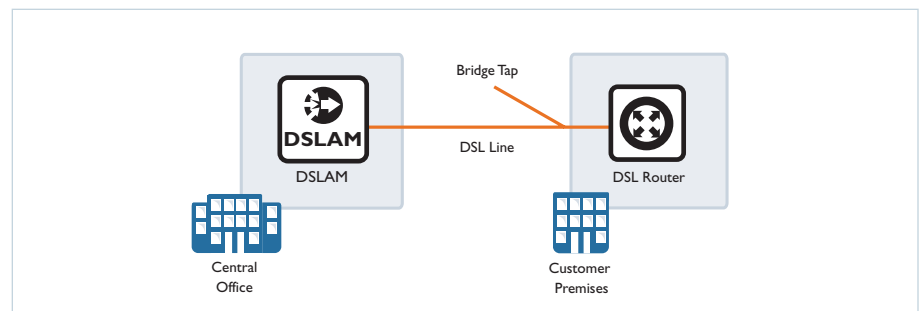


Figure 11: Bridge Tap

Load Coils

A load coil is a device placed on a local loop that is longer than 18,000ft., to boost the frequencies that carry analogue voice signals. Load coils are placed at 3000ft. intervals from either end, and at 6000ft. intervals along the wire. Load coils are usually installed to compensate for signal loss caused by bridge taps, but they cause distortion at those higher frequencies that carry digital information. All load coils need to be removed from the wires before any digital transmissions, such as E1/T1, ISDN, or ADSL, can be used on the local loop.

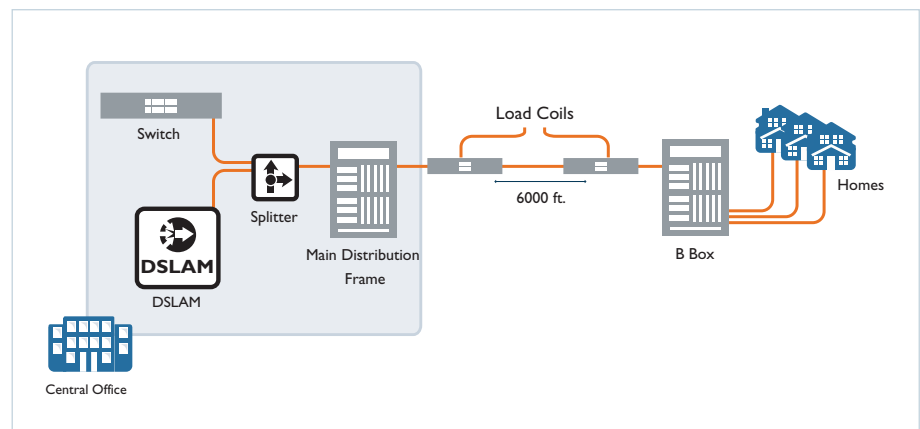


Figure 12: Load Coils

Crosstalk

Crosstalk is a disturbance in a circuit that is caused by the electric or magnetic fields of another telecommunication signal. This disturbance can cause a severe degradation in transmission. The two main types of crosstalk are Near End Crosstalk (NEXT) and Far End Crosstalk (FEXT). NEXT occurs when a strong local transmitter interferes with another collocated receiver and is the most problematic. FEXT is when there is interference at the receiving end.

Other DSL lines in the same bundle of wires may cause crosstalk with each other, depending on their frequency ranges. For example, if a T1 line is running in the same bundle with a DSL line, some of the frequencies may not be useable. The AM radio frequency, which goes up from around 600kHz, may also interfere with DSL lines.

| | |
|-----------------------------|---|
| Return Loss | Return loss is a measure of the ratio of signal transmitted into a system to the amount of the signal that is reflected back to the source. Return loss is caused by an incorrectly terminated line and can reveal line faults that are caused by mismatching. |
| Longitudinal Balance | It is important for xDSL services that the resistance to the flow of a current in a circuit (or impedance) to earth, for each conductor, is as equal as possible. This balance is known as longitudinal balance. When the line is balanced, there is no difference between the signals on the two conductors. |
| Noise | The total power in a transmission line is made up of the signal and noise. Noise is always present but it should always be kept as low as possible in relationship to the signal. Factors that introduce noise are: radio and television transmitters, power distribution systems, electrical machinery and mechanical vibration. |
| Impulse Noise | Brief, but large spikes of electrical interference (typically caused by power switching equipment). DMT modulation (which has a relatively long cycle time) is quite tolerant of this sort of disturbance. |
| Split Pairs | Split pairs occur when one conductor in a pair becomes separated from the other conductor. Split pairs result in noise, crosstalk and radiation, and seriously degrade xDSL services. |
| Gauge Changes | While conductors with different gauges are suitable for xDSL connections, mixing the gauges in cable runs can cause impairments that affect the line's ability to carry xDSL services. |

C. How Does Allied Telesis Support DSL?

Allied Telesis has a range of products that support a range of DSL connections to suit the needs of different customers.

Customer equipment

Medium to Large Business Routers

Allied Telesis provides SHDSL support for the medium to large business market with the AR442S. This router includes the following features:

- 2 pair SHDSL with bonding
- 5 LAN ports
- 1 PIC slot
- 1 Asynchronous port
- Tagged VLANs
- Fully featured routing support, including RIP, OSPF, BGP
- IPv6 support
- IPsec VPN
- Multi-layered QoS
- Stateful Inspection Firewall

The iMG634A supports ADSL over POTS lines (Annex A) and the iMG634B supports ADSL over Integrated Services Digital Network (ISDN) lines (Annex B). These routers include the following features:

- ADSL2+
- 2 VoIP ports
- 4 LAN ports
- Network Address Translation (NAT)
- RIP and static routing
- Stateful Inspection Firewall
- Rate Limiting
- Tagged VLANs

Small Office and Branch Office Routers

Allied Telesis provides ADSL support for the small office and branch office market with the AR440S for ADSL over POTS lines (Annex A) and the AR441S for ADSL over Integrated Services Digital Network (ISDN) lines (Annex B). These routers include the following features:

- 1 ADSL port, with dying gasp
- 5 LAN ports
- 1 PIC slot
- 1 Asynchronous port
- Tagged VLANs
- Fully featured routing support, including RIP, OSPF, BGP
- IPv6 support

- IPsec VPN
- Multi-layered QoS
- Stateful Inspection Firewall

Small Business and Small Office Home Office (SOHO) Routers

Allied Telesis provides ADSL2+ support for small businesses and the small office/home office market with the AR236E router⁴. The AR236E router includes the following features:

- ADSL2+
- 1 LAN port
- 1 USB port
- Network Address Translation (NAT)
- Stateful Inspection Firewall
- DHCP

Service provider equipment

integrated Multiservice Access Platforms (iMAPs) (formerly known as DSLAMs)

Allied Telesis' 7000 and 9000 Series Integrated Multiservice Access Platforms (iMAPs) enable service providers to deliver carrier-class services to enterprises of any size. This family of iMAPs enable service providers to offer advanced simultaneous triple play services, such as high-quality voice, tiered IP/Ethernet data services, and broadcast quality IP video.

The Allied Telesis 7000 Series iMAPs enable service providers to offer advanced ADSL services. The 9000 Series iMAPs support a range of ADSL and Ethernet service modules to support customers' needs. For example, the Allied Telesis 9000 Series iMAPs support a variety of service modules, including:

- 24 x ADSL ports (with splitters)
- 16 x ADSL ports (without splitters)
- 10 x 10/100 Ethernet ports
- FX10SF – single mode fibre connection up to 10km

⁴ The AR236E is currently only available in the Asia Pacific region

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