

Analysis of ADSL and xDSL

A comparison of technologies and delivery methods

White Paper

Document Control	
Document	PLR01_WP-ADSL_DM01_09-06.doc
Date Created	25 th May 2001
Version	V 1.00
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Introduction – Part 1

Document Purpose

This document is intended to provide an analysis of the “new technology” broadband digital services available to subscribers over copper pair. The document is aimed at comparing the access technologies available. Access technologies are those technologies, which can be used to connect a client site or office (including home office) to the PoP (Point of Presence), of the ISP (Internet Service Provider).

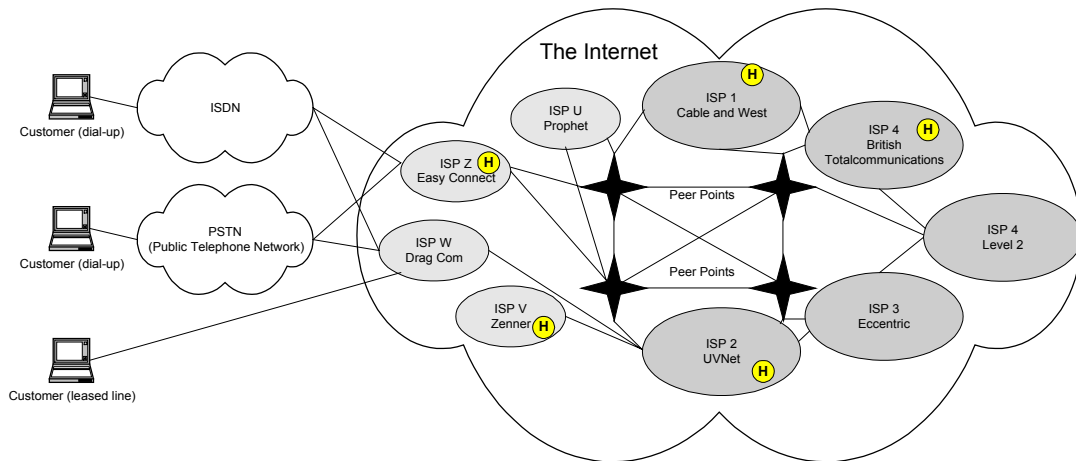
A short overview of the Internet will be included for completeness.

It is the objective of this paper to explain the benefits and disadvantages of various technologies, such that a more direct comparison can be made between the various cost models.

Introducing: The Internet

The Internet consists of a number of elements. All stations (electronic processing devices) that have a network that attaches to the Internet effectively become part of the Internet.

The elements that are traditionally thought of as making up the Internet are the Service Providers that offer network connectivity and the hosting services that make up the “content” of the Internet.



In a classic topology an ISP will sell a dial-up or fixed (leased line) access to the ISP network. The ISP network is then linked to an upstream (backbone) ISP or peer point (or both).

Upstream ISPs tend to be very large organizations, typically the country communications provider, such as BT.

Smaller ISPs connect to the larger ISPs or peer points with high bandwidth links. The links will be sized to avoid congestion under normal circumstances, but based on the fact that Internet usage is unpredictable, congestion can occur, for example; when tickets for a popular event go on sale.

Early Internet Access Technology

As stated previously, the classic Internet connection comes in three varieties:

- 1) **PSTN Dial-Up** – Using a modem to convert the digital signals that computers use to a audio signal that can pass across a public audio network (the telephone system).
- 2) **ISDN Dial-Up** – An enhancement upon analogue telephone lines is the ISDN, Integrated Services Digital Network. The ISDN service is capable of interacting with the analogue telephone network, but it also supports much more. Computers with an appropriate interface can connect directly at up to 128Kb/s using an ISDN2 digital signal. In this case the computer sends data digitally. The computer receiving the call also accepts the call digitally, so there is no need to degrade the signal converting it from one encoding system to another.
- 3) **Leased Line** – A point to point service is purchased from a telecommunications provider, such as BT. The line is specified at a bandwidth, where the higher the bandwidth, the more expensive the service.

Technology Analysis

PSTN – Modem Access

Advantages

Telephone lines available everywhere
 Low initial set-up costs
 Dial technology – any to any connectivity

Disadvantages

Slow connection times
 Bandwidth limited to 56Kb/s
 Call costs significant for frequent use

ISDN – Digital Dialed Access

Advantages

Digital technology
 Low initial set-up costs
 Dial technology – any to any connectivity

Disadvantages

Slow connection times (faster than PSTN)
 Bandwidth limited to 128Kb/s
 Call costs significant for frequent use

Leased Line – Digital Fixed Access

Advantages

Digital technology
 Always-on – no dial delay
 Bandwidth guaranteed
 Any bandwidth available

Disadvantages

Expensive for occasional use
 Point to point dedicated connection
 Set up costs significant

It is therefore typical that the typical user matrix would be:

Technology	Typical User
PSTN modem dial	Home user or very small office
ISDN digital dial	Home office or small office
Leased Line	Business users and frequent users

Enter DSL

Digital Subscriber Loop or DSL is available in many variations that mainly differentiates the way the signal is transmitted across the copper wires, however specifically two technologies will be focussed upon ADSL and SDSL – Asymmetrical and Symmetrical DSL.

Digital Subscriber Loop technologies seek to bring the access characteristics of the fixed networks with the costs of an occasional usage tariff.

The most significant point about DSL technologies is that the **technology is only applicable to the copper local loop**. Within a given area, typically 2-3 miles, all of the buildings that connect to the public telephone network are cabled to the local **Exchange**.

DSL technology can therefore be used to connect local sites together at high speed over quite poor quality copper wires that were originally installed for telephone services. Subject to distances and line quality, speeds of up to 2Mb/s can be achieved. This is typically 30 to 50 times faster than dialing up with an analogue modem.

Due to the modulation characteristics of DSL, the part of the signaling spectrum that is used for voice communications is not used, therefore there should be no interference with any voice services that are passing over the adjacent copper wires.

A filter may be required to ensure that this is the case, but the key element is that the phone wire that exists already is used to carry the DSL signal, therefore there is no need to run a new circuit in.

DSL Limitations

DSL is being rolled out extensively in highly populated metropolitan areas, as the opportunity to get the highest number of subscribers, from the minimum investment exists.

Unless the service provider has an Internet Point of Presence at the metropolitan area selected to offer the service, the typical way to access the Internet over ADSL is to aggregate all of the subscribers at a DSL-AM Access Multiplexor. A connection is set up from the DSL-AM to the Internet, however in the interests of keeping costs low, the connection does not have sufficient bandwidth to support all of the subscribers at the same time, using their full DSL bandwidth.

Oversubscription

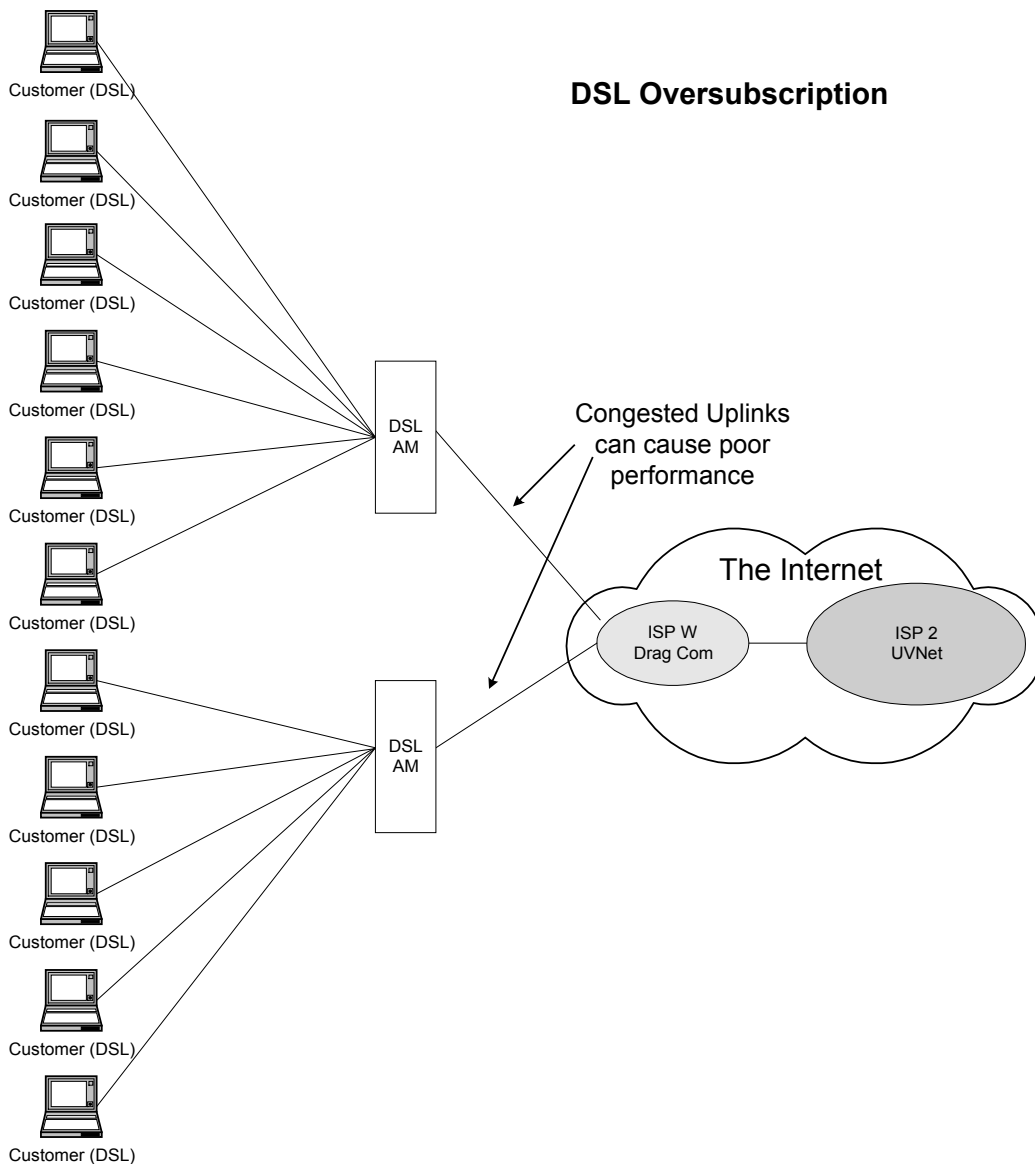
Having a high bandwidth connection to the DSL-AM is only part of the story. Oversubscription is used to keep costs low. That is, the connection between the DSL-AM and the Internet is not sized by taking the number of users and the speed of access that the users have and multiplying them.

Typically an oversubscription rate of 20:1 is used to allocate bandwidth between the DSL-AM and the Internet. The theory is that not all users will use the service at the same time, which is somewhat true. Bearing in mind that the target customers of this service are small offices and high usage home users, it is reasonable to conclude that the typical peak usage patterns will be Monday to Sunday 9am to 9pm!

In a situation where half of the users are home users are not in the house during the week, the small businesses that have a DSL connection a 500Kb/s to the DSL-AM will be sharing the onward connection of the equivalent of 500 Kb/s between 10 sites.

Presuming all of the sites require access at the same time, each will receive approximately 50Kb/s, slightly less than can be achieved using an analogue modem.

Many subscribers that have signed up to an ADSL service based on a 20:1 oversubscription rate have complained bitterly about the quality of service they received. In addition, due to the budgetary conscious nature of the scheme, technical support organizations are not always focussed on a high level of customer service.



PTT and ISP relationship

The PTT (in the UK - British Telecom) provides the wire and some of the equipment at the exchange, then feeds the data back to the ISP (your Internet provider) over an ATM virtual circuit.

Bear in mind that BT do not operate a fault rectification service outside "normal" working hours and that the cost model does not permit extensive resources to be allocated to resolve faults.

It is very important to understand that the whole cost model is volume based, therefore the higher the number of subscribers, the better. In this case it is not economic to provide high quality support to customers, using a well-staffed centre of technical excellence as the costs are simply too high. The process relies on there being a small number of faults that require manual intervention.

DSL Done Well

DSL can be used to deliver a high quality of service when the upstream bandwidth is allocated and reserved according to the client's needs.

It is possible to allocate specific minimum bandwidth allowances to each client, so that a minimum service level is achieved at all times.

At off-peak times, users can use the additional upstream bandwidth to get high speed connections up to the DSL access speed when available. At peak times, the minimum committed bandwidth is available.

Other Applications

DSL can be deployed where there are the following characteristics of the network required:

- 1) High Speed e.g. up to 3Mb/s.
- 2) Short haul e.g. up to 3 miles.
- 3) Copper pairs available between sites.
- 4) Serial connectivity required.

A typical use for this technology would be to connect two offices together that were a few kilometers away from each other.

DSL modems can even be used within the same building to distribute network services to various users with specific requirements.

DSL drawbacks

Security

Where DSL has provided a connection to the Internet it almost in all cases creates an increased security risk, due to the nature of the technology, the client site is "always on" therefore always connected to the Public Internet.

It is highly advisable to install a physical firewall between the internal (clean or trusted) network and the external (dirty or untusted) Internet.

Upstream/Downstream

A fact not overly publicised is that the nature of ADSL is that it is asymmetric, therefore the maximum data rate is different in each direction. The typical speed **to** the Internet is either 128Kb/s or with some providers, 256Kb/s – but organizations that send data to the Internet need high upstream speeds as well.

Quality of Service

Typically the Service Level Agreement (SLA) offered to DSL customers is poor (if an SLA is offered at all). There have been reports of the service between the customer site and the Internet failing for days at a time and the service provider not demonstrating any concern.

The Extras

Due to the low cost model, many essential additional services cost extra, particularly on the very low cost (e.g. less than £50 per month).

Delivery

It is very common for the ISPs to use USB (Universal Serial Bus) delivery, which does not typically plug straight into a Local Area Network (LAN). It is therefore difficult to integrate hardware, such as firewalls.

This normally means buying a more expensive ADSL service which is delivered on RJ45 (Ethernet).

Appendix A

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Technical

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Appendix B

Explanation of Services and Acronyms

ADSL

Short for *Asymmetric Digital Subscriber Line*, a local loop technology that allows more data to be sent over existing copper telephone lines. ADSL supports speeds of from 1.5 to 9 Mb/s when receiving data (known as the *downstream* rate) and from 16 to 640 Kb/s when sending data (known as the *upstream* rate). ADSL requires a special ADSL modem.

ADSL is growing in popularity as more areas around the world gain access, however the deployment model of many ISPs does not permit enough upstream bandwidth (from the PoP to the Internet) to cope with the large number of user demands placed upon the system. In particular, most ISPs do not offer any upstream bandwidth QoS (Quality of Service) measures to ensure a minimum bandwidth is available to each user.

DNS

Short for *Domain Name System (or Service)*, an Internet service that translates domain names into IP addresses.

Because domain names are alphabetical, they are easier to remember. The Internet however, is really based on IP addresses.

Every time you use a domain name, therefore, a DNS service must translate the name into the corresponding IP address. For example, the domain name *www.anydomain.com* might translate to *193.92.262.4*.

The DNS system is, in fact, its own network. If one DNS server doesn't know how to translate a particular domain name, it asks another one, and so on, until the correct IP address is returned.

DNS is particularly important in the provision of SMTP mail services. The SMTP gateway (or mail server) uses the "MX record" to convert an email address (*anyone@anydomain.com*) to the mail server's IP address for delivery of e-mail.

Denial of Service attacks are commonplace to DNS servers that are not adequately protected. In a recent event, www.microsoft.com was 'taken down' for several days due to the failure of the DNS systems, partially caused by hackers. Due to the fact that changes in the DNS configurations of companies must be propagated to all ISPs, any rectification of a failure can cause several days to resolve.

Firewall (stateful inspection)

A system designed to prevent unauthorized access to or from a private network. Firewalls can be implemented in both hardware and software, or a combination of both. Firewalls are frequently used to prevent unauthorized Internet users from accessing private networks connected to the Internet, especially intranets. All messages entering or leaving the intranet pass through the firewall, which examines each message and blocks those that do not meet the specified security criteria.

There are several types of firewall techniques:

- **Packet filter:** Looks at each packet entering or leaving the network and accepts or rejects it based on user-defined rules. Packet filtering is fairly effective and transparent to users, but it is difficult to configure. In addition, it is susceptible to IP spoofing.

- **Application gateway:** Applies security mechanisms to specific applications, such as FTP and Telnet servers. This is very effective, but can impose a performance degradation.
- **Stateful inspection gateway:** Applies security mechanisms when a TCP or UDP connection is established. Once the connection has been made, packets can flow between the hosts without further checking.
- **Proxy server:** Intercepts all messages entering and leaving the network. The proxy server effectively hides the true network addresses.

In practice, firewalls may use two or more of these techniques in conjunction with each other.

IMAP

Short for *Internet Message Access Protocol*, a protocol for retrieving e-mail messages. The latest version, *IMAP4*, is similar to POP3 but supports some additional features. For example, with IMAP4, you can search through your e-mail messages for keywords while the messages are still on mail server. You can then choose which messages to download to your machine. Like POP, IMAP uses SMTP for communication between the e-mail client and server.

POP

Short for *Post Office Protocol*. The de-facto standard protocol for e-mail clients to communicate with the e-mail server. See also IMAP.

PoP

Short for *Point of Presence*, a location from where services can be delivered. Internet Service Providers (ISPs) generally provide many POPs so that users can make a local call to gain Internet access.

SDSL

Short for *Symmetrical Digital Subscriber Line*, a local loop technology that allows more data to be sent over existing copper telephone lines. SDSL supports symmetrical speeds of up to 3 Mbps. SDSL requires a special SDSL modem.

SDSL is growing in popularity as more areas around the world gain access. It uses a variety of modulation techniques and is rate adaptable dependant on the quality of the copper wire that is being used.

SMTP

Short for *Simple Mail Transfer Protocol*, a protocol for sending e-mail messages between servers.

Most email systems that send mail over the Internet use SMTP to send messages from one server to another; the messages can then be retrieved with an e-mail client using either POP or IMAP. In addition, SMTP is generally used to send messages from a mail client to a mail server.

This is why you need to specify both the POP or IMAP server and the SMTP server when you configure your email application.

SMTP Feed

An Internet service may block the SMTP service from entering a client site. To permit SMTP to pass (an SMTP feed) the client may incur an additional charge. PCC normally includes SMTP feed with managed Internet bundles.