The Business Broadband Gap

Prepared by Gorham & Partners Ltd

for

Symmetricom®

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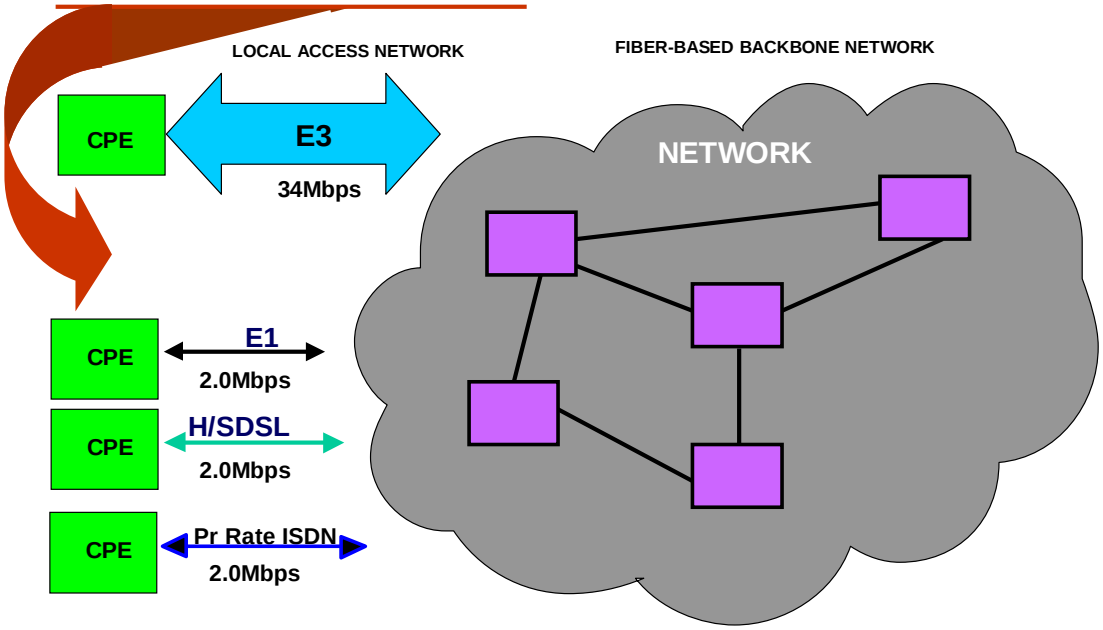
Defining The E-Gap

Small and medium-sized enterprises (SMEs, those with between 25 and 250 or 500 employees) often find themselves at an odd juncture regarding their broadband communications. On the one hand they find copper-based access methods, like ISDN Primary Rate, E1 (2.048 Mbps) and DSL, which provide them with limited bandwidth and flexibility. On the other hand, there are fibre-based broadband connections like E3 (34 Mbps), STM-1 (135 Mbps) and soon, the newly available Ethernet over fibre services, which can meet their needs for bandwidth, but are often very expensive and not widely available. It is between these two groups of access technologies that we find the "E-Gap or Business Broadband Gap" – that empty space in the market between copper fed E1 and fibre fed E3/STM-1 (both in terms of bandwidth and in terms of price).

Figure 1: The E-Gap



Effect on Service Providers

Service providers, particularly those OLOs (Other Licensed Operators) or new carriers who wish to offer a complete integrated voice, video and data solution find that their current portfolio of offerings fall short when it comes to the small to medium-sized business. In many cases, a single E1 or DSL circuit cannot handle both voice and data needs for these customers, and technical issues (mainly relating to interference in the telco outside plant) make it difficult to provision more than a few of these circuits to a single location. For these customers, a Primary Rate ISDN connection will also not offer the flexibility and data handling that they usually require.

E3 or Native Ethernet over fibre services would certainly fulfil these customer's needs, at least technically, but the high cost of such circuits and the limited availability of fibre to buildings make these access methods only practical for larger customers. For many service providers,

particularly the new competitive providers who must lease access facilities from incumbent telcos, the cost of access can comprise up 40% or more of their overall costs.

Effect on End Users

The small and medium-sized businesses finds themselves in the midst of the this E-Gap too – particularly as their needs for bandwidth to support emerging services grow. As we will discuss below, many SMEs find their current access methods to be inadequate for their current bandwidth requirements, but their budgets too limited to move up to higher bandwidth solutions like E3. They also find the widely available Primary Rate ISDN connections too limited and inflexible for their growing business needs.

This leaves SMEs abandoned in the middle of the E-Gap. Their current band width options do not adequately support the functionality they require for their communications and the next higher bandwidth options are out of their price range or not available in their area.

Local Access and the Small and Medium-Sized Business

Small and medium-sized businesses[1] (hereafter referred to as SMEs – Small and Medium sized Enterprises), have a wide-ranging variety of telecommunications and data applications, ranging from simple voice and Internet connections to truly "next-generation" applications like ASP, E-commerce and Intranets.

Among the "traditional" applications required by SMEs are the following:

- **Voice**: While analogue POTS (Plain Old Telephone System) or Basic Rate ISDN support is often used by SMEs, many of the businesses in this category require E1 or equivalent bandwidth for PBXs.

- **Internet**: Simple Internet access for e-mail and Web surfing applications is usually the bare minimum for SMEs, along with support for Web hosting and other "basic" Internet services. For Web hosting, there is little option except to lease an E1 line in order to provide adequate symmetric (two-way) capacity.

- **Video**: Two-way videoconferencing (along with related data conferencing) and one-way video for training, distance learning, and other applications.

- **Data Networking**: Broadband access for a host of data communications applications such as access to ATM/Frame Relay networks, financial network connectivity, CRM, etc.

In addition to these traditional applications, dozens of newly developed applications are beginning to make increasing bandwidth demands on SMEs, including:

- **VPN/Intranet**: Taking advantage of the economies of IP services, many SMEs are beginning to move from legacy private leased line networks towards IP-VPN networks, both within the enterprise (Intranets) and without (Extranets connecting a company with suppliers, customers, telecommuters and other organisations).

- **Converged Voice over IP (VoIP)**: Using voice gateways or IP-enabled PBXs, SMEs can increasingly carry their voice and data traffic over a single connection, utilising dynamic allocation of bandwidth to more efficiently use their circuits.

[1] according to the EU statistics, there are over 20 million businesses in the EU in the 50-249 employee range representing some 99.8% of all business enterprises; extending this to 499 employees increases the number by a negligible amount.

- **Distributed Computing/ASP**: Many SMEs find that "owning" and maintaining all of their own applications' support for non mission critical applications (or for those outside of the core competencies of the SME) is a great expense, both in terms of cash and also in terms of costly and hard-to-find IT personnel. Outsourcing these applications to expert third parties and accessing them via IP networks is increasingly a viable option to doing it all in house.

- **E-commerce**: Much hyped in recent years, and similarly much belittled during the dot.com downturn, e-commerce remains a vital application for SMEs. Using e-commerce to reach more customers, at reduced expense, with better integration into back-end inventory, supply and human resources continues to be a compelling application for most SMEs.

Services for Today's Small and Medium-Sized Business

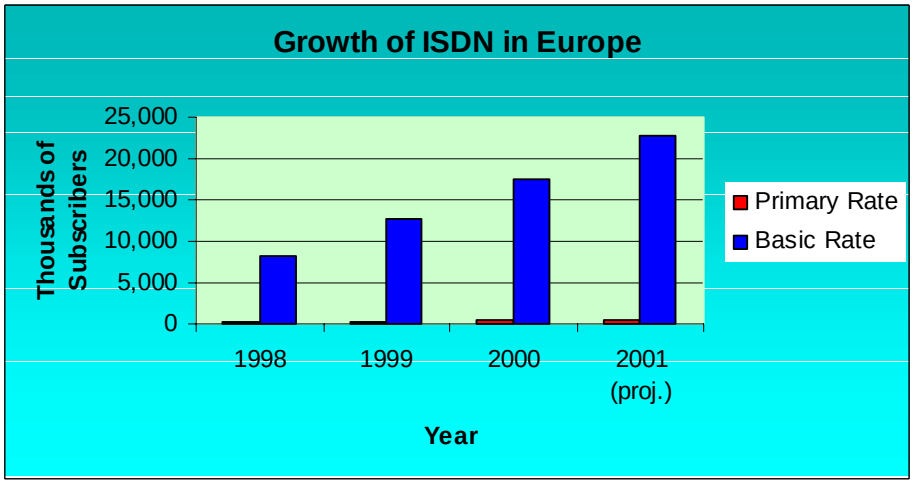
To explain the E-Gap more fully, it is instructive to look in more detail at today's available access options for the small and medium-sized business.

Below the E-Gap

ISDN Services

Within the European Union, unlike North America, ISDN services are widely available. Most European countries have available both Basic Rate and Primary Rate services although the costs vary quite widely from country to country. The Basic Rate service generally provides a multiple of 64 Kbps channels over one to four two-wire copper circuits; in some cases, two channels may be bonded together to provide a 128 Kbps data link for Internet access. The Primary Rate service provides up to 30 x 64 Kbps channels generally used for voice traffic from a PBX but also usable for data. Unfortunately, the Primary Rate services do not provide the flexibility that newer technologies allow.

Figure 2: ISDN Growth in Europe



Source: Siemens

To date, research carried out by Gorham & Partners, suggests that relatively few ISDN subscribers have converted to ADSL with the exception of Germany where Deutsche Telekom is deliberately offering ADSL as an possible upgrade from ISDN, in speed terms, for the residential user. For the business user, ADSL has little to offer in comparison to Primary Rate ISDN due to its low data rates and asymmetry.

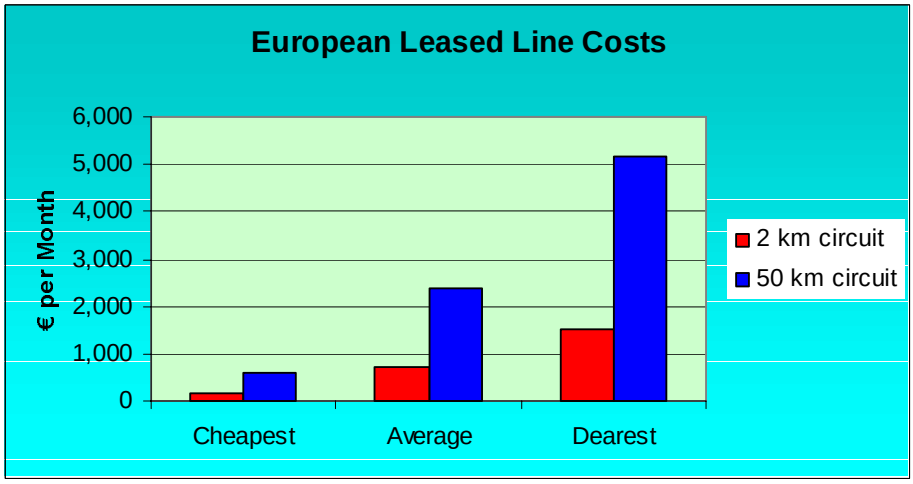
E1 Services

The service provider answer to an SME looking for connectivity has long been the E1 circuit. With a guaranteed bandwidth of 2.048 Mbps, high reliability and wide availability (particularly with the advent of H/SDSL-based E1 provisioning over the past decade), the E1 is a good product for many business users, typically priced between €300 and €600 (based on a 2km line[2]) per month

There are some shortcomings, however, including:

- **Variable pricing:** the advent of competitive providers, mainly in metropolitan areas, has lowered E1 pricing significantly in some places, while in others, the dominant, former monopoly providers are still able to command a premium price for the service.

Figure 3: E1 Pricing is Variable



Source: Oftel, OECD & EU Commission

- **Lead Time:** in many cases, the lead time for the provision of an E1 line is considerable, sometimes running into months[3]. After pricing, lead time is generally regarded as the largest problem with obtaining a leased line.

- **Competition:** competition for the provision of E1 lines for access to a local point of presence for the major pan-European network providers is still undeveloped with customers having to rely mainly on the incumbent operator for this leg of the service.

- **Availability:** while E1 lines are readily available in most metropolitan centres, often with a choice of supplier, once outside these centres, lines are not always available and when they are, usually only from the incumbent operator.

- **Technical limitations to multiple E1 connections to a single location:** The underlying line coding used to provide E1 speeds over copper twisted pair lines is inherently noisy and interferes with other signals being carried in adjacent copper pairs. Service providers are limited to offering only a few E1 lines per bundle group because of this interference – often limiting the number of E1s that can be provisioned to a single location.

[2] Yankee Group Europe
[3] Yankee Group Europe research suggests that in Germany and the Netherlands, waits of 14 weeks are common.

- **Limited bandwidth flexibility:** When an E1 line is paired with a traditional Integrated Access Device (IAD) to provide both voice and data services, the bandwidth of the E1 line is allocated into fixed channels for each service – this is an inefficient use of bandwidth since voice services are often not used at their full capacity, and such a fixed allocation is unable dynamically to allocate voice bandwidth for bursty data traffic needs. This means that many SMEs will need to utilise separate E1s for voice and data/Internet applications, increasing network and telephone costs, CPE costs and overall network complexity.

E1 CPE and CPE Pricing

E1 Customer Premises Equipment (CPE) is widely available and relatively inexpensive – for basic E1 services a CSU/DSU can be as little as €550. However, Integrated Access Devices (IADs) for E1 are considerably more expensive (typically greater than €1,200), and equipment for IMA E1 is also more expensive than low end CSU/DSUs. Additionally, the customer will need to purchase or lease a router to connect between the V.35 interface on the CSU/DSU and their office LAN, as a native Ethernet interface is not usually offered on E1 equipment.

DSL Services

During the past several years, Digital Subscriber Line (DSL) technologies have offered both businesses and consumers a new generation of E1-like services at greatly reduced costs. Millions of businesses and consumers have adopted DSL from two groups of service providers.

The first and most applicable to SMEs, are Symmetrical DSL (generally based on proprietary US style H/SDSL, not to be confused with the ETSI European standard SDSL) services, offered mainly by competitive local exchange carriers (CLECs). These services utilise unbundled network elements (UNEs) (or leased copper pairs) from the telco and provide symmetrical bandwidth up to 2.0Mbps, generally using proprietary US style H/SDSL technology, often needing more than one pair of wires. A few of the second group, incumbent European telcos, are slowly beginning to offer business class symmetrical DSL services. However, to date, they have mainly focused on the low-end small business (with 4 to 6 exchange lines or less) and residential markets with Asymmetrical DSL (ADSL). By its nature, ADSL with a much faster downstream than upstream speed is not well suited to the needs of the larger SMEs.

Symmetrical DSL services are typically less expensive per megabit than E1, with most competitive providers offering 2.0 Mbps for prices between €220 and €300 per month. DSL CPE is also relatively inexpensive, with low-end routers costing approximately €300 and more fully featured routers (including such features as firewall, VPN, etc.) costing closer to €750.

ADSL services can offer abundant downstream bandwidth – up to 8 Mbps – and are typically limited to upstream bandwidths of around 1/10 of this, considerably lower than E1. However, for reasons of marketing and network capacity, most European ADSL providers limit the maximum downstream speed to 2 Mbps and just 512 Kbps in the upstream direction. Additionally, some European telcos insist on the use of Network Address Translation (NAT) which precludes the use of ADSL services to host web sites. Because of this fact, many SMEs find these services to be inadequate to their needs, as this asymmetric nature doesn't enable common services such as Web or email server hosting, videoconferencing and E-commerce.

Business class H/SDSL services suffer from several shortcomings:

- There are significant limitations to availability, due to copper loop length limitations.
- Proprietary H/SDSL technologies, like E1, are noisy and prone to causing interference in the twisted pair binder group, so deployments may be limited by this factor.

- H/SDSL services have to date been offered mainly by incumbent telcos as cheaper (to them) replacements for leased E1 copper lines. However, some of the new data CLECs have also been tentatively offering such services and these providers have been experiencing severe financial difficulties and indeed most have left the market due to bankruptcy.

Fixed Wireless

Another recent entrant into the access market are fixed wireless providers using LMDS (local multipoint distribution system) or MMDS (Multi-channel Multi-point Distribution Service) technologies. While such services have been offered in Germany, France, Spain and the UK, the two UK providers have both gone into bankruptcy and those in the other three countries only claim a few thousand subscribers between them[4]. The initial proponents of such services offer a variety of speeds, with E1 equivalent services usually priced between €800 and €1,250 per month.

The fixed wireless market has so far been very unsuccessful for service providers, with most of the initial entrants into the market failing and falling into administration or bankruptcy. Fixed wireless is relatively easy to provision where offered, as no physical link is needed between the service provider and customer, but the cost of the technology and the slowness of many countries to issue operating licences for the necessary radio spectrum has limited deployments to date, and line-of-sight limitations mean that most businesses are out of reach of existing deployments.

Cable Modems

Within Europe, cable modems have become one of the dominant forces in the provision of broadband services, but only to the residential customers in select countries. When the cable TV licences were issued, there were requirements in most countries to pass a certain proportion of house within a given time span; no such provision existed for businesses. The nature of the cable modem service is also unsuited to the business user due the inherently shared nature of the coaxial cable used and the consequent concerns over data security. Today, there are probably more cable modems in Europe than there are ADSL modems[5] with the cross over expected before the end of 2002. However, very few, if any, of these are used by medium sized businesses and so have no relevance to this White Paper.

Above the E-Gap

E1 IMA

To meet the needs of customers requiring more bandwidth than a single E1 circuit, a standard called Inverse Multiplexing over ATM (IMA) has been established although it has not become widely available in Europe to this date. Using IMA, multiple E1 circuits can be configured to behave as a single, higher speed connection or data pipe. Although not widely available, E1 IMA works well in practice, but is limited in scalability due to the inherent noisiness of E1 – while it is possible to inverse multiplex multiple E1 lines, most service providers offer a maximum of only 2 E1 circuits, or 4 Mbps total bandwidth. This requires the customer to both lease two E1 lines and purchase or lease the necessary IAD as well.

[4] 10,600 at the end of October 2001 according to IDATE.
[5] ECTA LLU Scorecard – October 2001

E3 Services

Moving up from copper-based broadband services, SMEs will find the gap that defines the E-Gap – the next service level available from most providers is the 34Mbps E3. Provided using high bandwidth facilities such as optical fibre or microwave radio (rarely available to the SME in Europe), E3 connections are priced much higher than E1, with typical pricing in the range of €4,000 (European average for a 2 km circuit[6]) to €32,000 (European average for a 200 km circuit) per month; exact pricing will depend on provider and circuit length.

Like E1, E3 facilities can be established with a mix of both voice and data services over a single line, and – again like E1 – this bandwidth mix is not typically dynamically allocated. In other words, the E3 line can be configured with a certain amount of bandwidth allocated for voice channels and a certain amount for data and this allocation can not be changed "on the fly" by the end user.

Fractional E3 services, using a full E3 access line, but throttling the throughput down to a lower level, are offered by some carriers in the US, but are almost unknown in Europe. Such services would be less expensive than full 34 Mbps E3 services, but because the full E3 facility is required to provide them, are typically more expensive than E1 or multiple E1 solutions.

E3 services are available in most European countries but the take up by business has been small and they represent a very small proportion of the broadband capacity available. Generally, only large companies need or are willing to pay for circuits over E1 capacity and in these cases, are more likely to go straight to a 155 Mbps STM-1 optical fibre than an intermediate capacity E3.

Metro Fibre Services

The newest entrants into the local access market for SMEs are the next generation optical Ethernet providers. These companies offer customers connected to the metro fibre ring a native Ethernet services at speeds of 1, 10, 100 Mbps or faster. Typical pricing for these new services is very variable, with some providers charging around €3,000 per month for a 10 Mbps service, and others charging the same amount for a 100 Mbps connection. Because these services present a standard Ethernet interface to the customer, CPE requirements for the SME are relatively inexpensive.

Most metro fibre Ethernet services are extremely flexible; due to the capacity of the fibre connection, and additional bandwidth can often be provisioned "on the fly" using Web-based account management software.

The biggest drawback to this emerging access method for most businesses is simply one of availability. Only a minute percentage of large businesses are currently connected to one of these metropolitan fibre networks. For the present, the metro fibre services have little to offer to any but the most bandwidth capacity hungry user who is lucky enough to be passed by such a fibre supplier.

At this point in time, there are no statistics available for businesses and offices passed by fibre within the EU.

[6] EU Commission Fifth Implementation Report

Table 1: SME Access Comparison

Technology	Bandwidth	Cost/Month	Availability	Support for Voice and Data	Dynamic Bandwidth Allocation?
E1	2.0 Mbps	€300-€1,500	High	Yes	No
E1 IMA	4.0 Mbps	€600-€3,000	Low	Yes	No
H/SDSL	To 2.0 Mbps	€300-€1,500	Low to Medium	Limited (VoDSL)	Limited (VoDSL)
Fixed Wireless	2.0 Mbps	€800-€1,250	Low	Yes	No
E3	34 Mbps	€6,000+	Low	Yes	No
Ethernet over Fibre	10Mbps+	€3,000+	Very Low	Limited	Yes

The E-Gap

When comparing the various SME access options listed in the table above, the nature of the E-Gap becomes obvious. For many SMEs *today's access costs too much, is frequently not available and delivers too little!*

E1 Is Not Enough

As mentioned above, E1 has been the mainstay of the larger SMEs for decades. Unsurprisingly, what was once a high-end service now falls short of application demand for many businesses, 2.0 Mbps is quickly eaten up by existing voice requirements from the PBX and even basic data requirements. For example, using a not-so-conservative 4:1 oversubscription ratio, it takes only 120 voice lines to utilise a full E1; similarly, 120 Internet users sharing at E1 would be guaranteed only 16 Kbps of bandwidth during simultaneous usage – significantly less than a dial-up connection for each.

As mentioned above, using E1 IMA can increase this bandwidth, but only to a limited degree due to provisioning issues, additional equipment requirements and limited availability.

E3 – If Available – Is Often Too Much

ON the other hand, a full E3 connection, with its 34 Mbps, offers more than enough bandwidth for the vast majority of SMEs, but at between €4,000 and €32,000 a month, depending on circuit length, is simply too expensive for all but the largest of these. Additionally, because most E3 circuits are provisioned over fibre optical fibre facilities, many SMEs who would consider such a service will require an expensive new installation with a lengthy waiting period, even assuming that the services are available at their location.

Today's DSL Offers Fall Short

DSL services have promised broadband access for dialup prices, and indeed they do provide that for residential consumers and very small businesses. When the more sophisticated and bandwidth intensive needs of SMEs are considered, current DSL services do not make the grade. Proprietary H/SDSL services are limited to E1 speeds and require not just one but two pairs of wires (equipment to provide bonded H/SDSL services – similar to IMA E1 services – is available, but has not been widely deployed by any provider in Europe). In addition, these services are often unreliable and are offered by providers that are increasingly suspect as viable business concerns.

Fibre Is Great, When You Can Get It

Next generation Ethernet over Fibre solutions have many of the characteristics needed to bridge the E-Gap – flexible bandwidth of 10 Mbps or greater, support for converged voice, video and data services and relatively low pricing – but the vast majority of businesses (of any size) simply are not connected to the fibre network, and will not be for some time.

10 Mbps Is the Sweet Spot

The level of service offered by these fibre services, however, does fit the needs of SMEs extremely well. If one were to envision what kind of service these businesses require, there would be a few "must have" criteria:

- **Speed to support current and future services.** Data/Internet access speeds of 10 or more Mbps plus bandwidth to support PBX-based or VoIP voice services, with flexibility in bandwidth provisioning to allow lower speeds for smaller businesses and rapid growth as needs change.

- **Affordability**. Service pricing at or below current E1 pricing levels for lower speed variants, well below E3 for higher speeds.

- **A "natural" interface type and speed.** CPE with an E1/100Base-T interface for easy connection to the ubiquitous existing LAN router/hub equipment, plus standardised interfaces for connection to PBX systems.

- **Ability to leverage copper infrastructure.** Fibre to the building is far from being a reality for most businesses, so the ability to access the existing copper twisted pair infrastructure to assure availability and affordability.

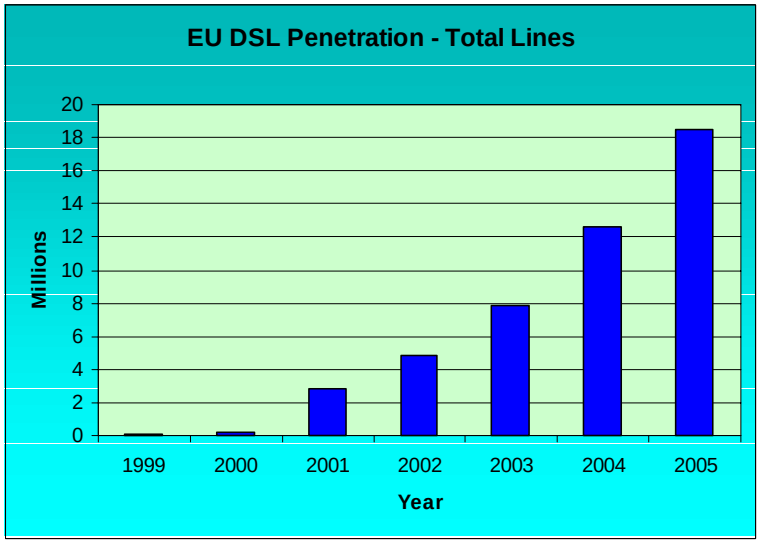
- **Quality of Service (QoS) Enabled Dynamic Bandwidth Allocation.** Utilise ATM QoS mechanisms to assign bandwidth to different applications while enabling a full range of services (voice, video and data) over a single connection.

A New Alternative: Bonded G.shdsl

One way to provide this "gap bridging" type of service is to utilise the new generation of DSL – the ITU standard G.shdsl – in a bonded multi-line service over inexpensive existing copper twisted pair UNEs. Utilising a device with the capability to bond up to 4 G.shdsl connections allows service providers to cheaply and easily provide services with speeds up to 9.2 Mbps to SMEs which have outgrown their E1s and are not ready to make the leap to E3.

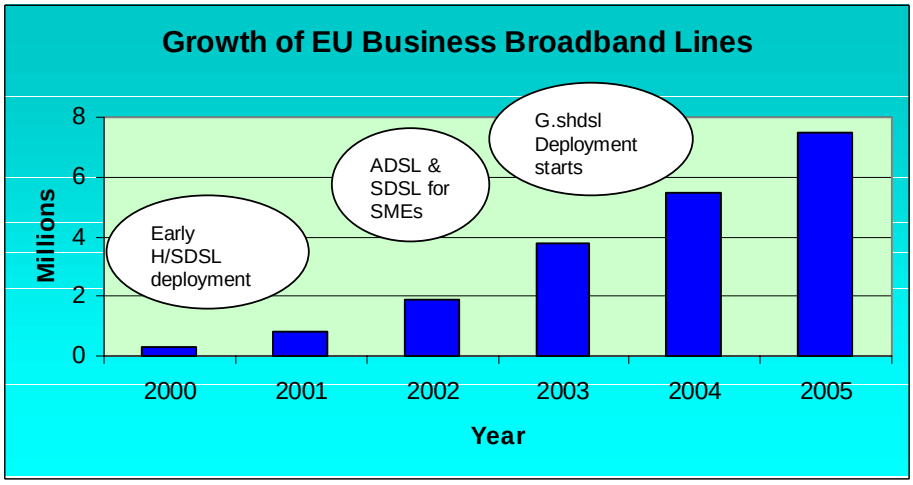
Figure 4 below presents a view of the overall European market projection for the number of xDSL users, both residential and business. The data behind this chart has been compiled from a wide number of up-to-date sources.

Figure 4: European Broadband Projections



Source: Gorham & Partners Ltd 2002

Figure 5: European Business Broadband Growth



Source: IDC & Gorham & Partners

The chart in figure 5 specifically covers xDSL broadband lines for business use; it excludes E1 and other leased lines.

How is this different from E1 IMA or traditional H/SDSL business services? It is different in several ways, including the following:

- **G.shdsl vs. H/SDSL.** G.shdsl is an international standards-based DSL, unlike the H/SDSL used to provide many E1 services. It was designed from the start as a "friendly" DSL, with very low noise characteristics and a very low probability of interfering with other services in adjacent copper pairs. Where only a few E1 lines can be placed in a single binder group, G.shdsl was designed to be spectrally friendly with up to 24 of the 25 pairs of lines in a 25pair binder group able to carry G.shdsl signals without interference.

- **Access to Fibre Backbone over Copper.** Where E1 or H/SDSL services can offer only relatively limited speeds – nowhere near the natural 10 Mbps interface to Ethernet based

systems that fibre over Ethernet systems offer – bonded G.shdsl can easily scale from 2.3 Mbps all the way up to 18 Mbps or more.

- **Greater Reach.** G.shdsl has a loop reach of up to 20% greater than proprietary H/SDSL systems and can be easily repeatered for very long loops. G.shdsl can also be offered over longer loops at lower speeds – but the ability to bond up to four lines together into one data channel means that even if the speed of each line was scaled back by 33% to increase loop length, a 6 Mbps service could still be offered.

- **Reliability.** By distributing communications over multiple UNEs, a bonded G.shdsl system has less single points of failure than an E1 or H/SDSL service. If one of the UNEs experiences a failure anywhere in the network (a physical line break, a misconfiguration in the exchange, etc.), the remaining connections would continue to work and still provide a high bandwidth service until that UNE was repaired.

- **Support from Major Infrastructure Vendors.** G.shdsl is an international standard, and unlike proprietary H/SDSL, is already supported by major DSLAM, chipset and other infrastructure vendors. The DSLAMs already in place in many service providers' networks, for example, can easily accommodate G.shdsl with simple and inexpensive line card upgrades.

- **Higher revenues with lower capitol investments.** Bonded G.sdhsl uses the copper telephone wires that are already in the ground and the current installed base of DSLAMs. Moreover, it gives businesses the high speed LAN/Internet interface they require and uses ATM within the carriers network, thus integrating simply into each network.

How Bonded G.shdsl Fits Into a Service Provider's Network

Bonded G.shdsl systems can fit into many different service provider deployment scenarios. Three of the most likely initial applications are:

1. **Circuit Emulation.** As a replacement for existing E1 or ISDN PRI facilities to transmit voice from a customer building to the Public Switched Telephone Network (PSTN).

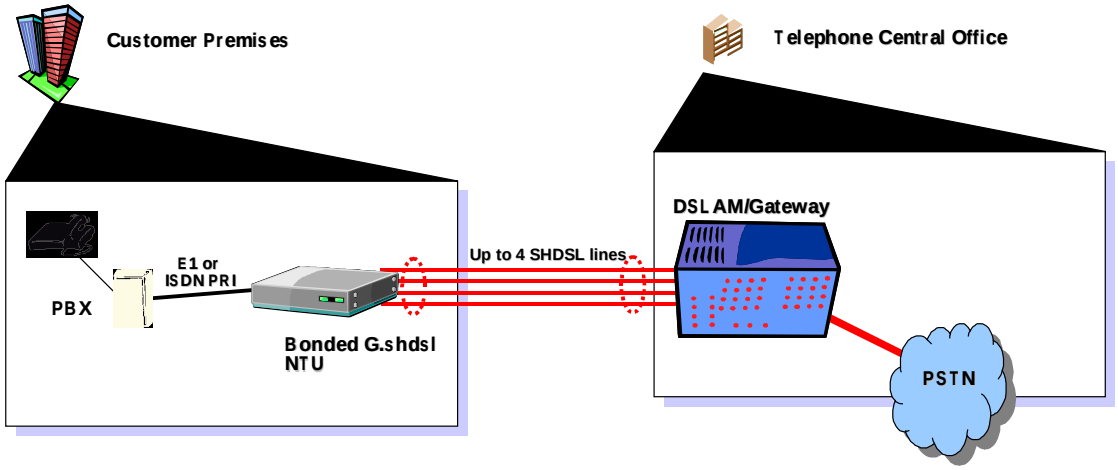
2. **Corporate Networking/Leased Line.** As a local transport method for connecting SME offices to an ATM, other private data network or remote office.

3. **High Speed Internet**. As an access method between the customer premises and a DSLAM located at the exchange, and also as a means of providing high speed access between ISP regional hubs and the central office.

Circuit Emulation

Bonded G.shdsl can be incorporated in a PTT or competitive carrier's network as the "last mile" link for reliable and extended range E1 PRI leased line service for voice. In this scenario, a G.shdsl Network Termination Device (NTU) is installed at the customer premises as far as 5 Km from the telephone central office. The G.shdsl is then terminated in the in the central office in a DSLAM with gateway functionality and passed on to the PSTN.

Figure 6: The Circuit Emulation Scenario

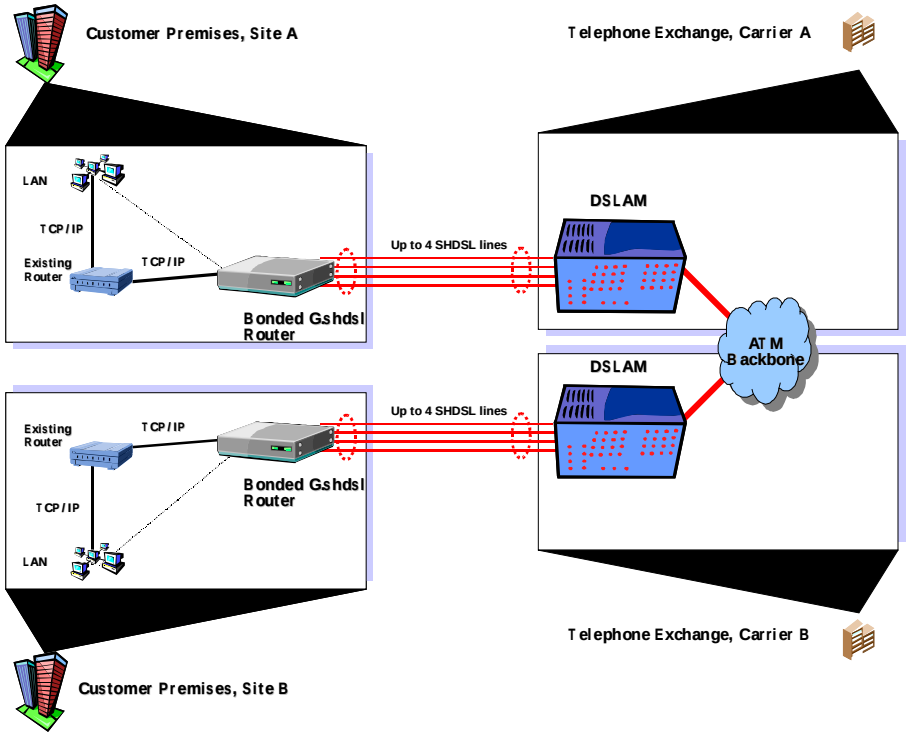


Circuit Emulation

Corporate Networking/Leased Line

Bonded G.shdsl can be implemented in an enterprise network configuration providing access to an ATM private network or an IP VPN. In this scenario, the bonded G.shdsl system can be used at each office location (branch or headquarters) with an appropriate number of G.shdsl lines enabled for each location to meet their bandwidth requirements. On the customer premises side, the bonded G.shdsl CPE would be connected to directly to the data LAN or to an existing router,, while on the network side, the G.shdsl lines would be terminated at a standard G.shdsl-enabled DSLAM with ATM virtual circuits connecting remote locations to each other. This scenario is demonstrated in the diagram below.

Figure 7: The Corporate Networking Scenario

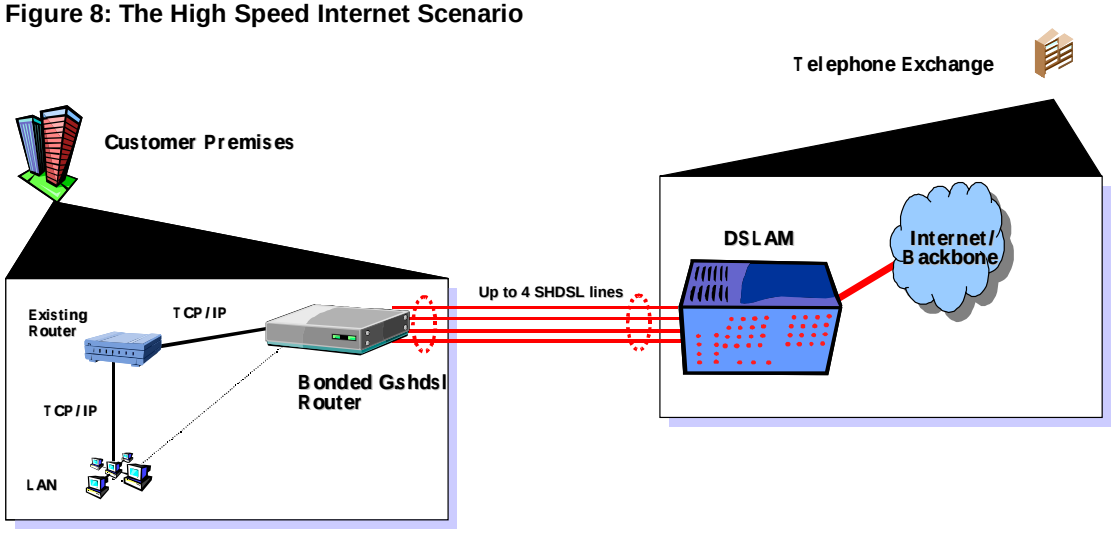


Corporate Networking/Leased Line

High Speed Internet

In a Internet service model, Internet and other IP services are carried between the central office G.shdsl-enabled DSLAM and the customer premises over multiple G.shdsl connections. In the customer premises, the bonded G.shdsl access device would be connected to the customer's LAN through existing routers or directly, while on the central office side, ATM virtual circuits would carry data upstream from the Central Office to the ISP's regional POP The figure on the next page demonstrates this application.

Figure 8: The High Speed Internet Scenario



High-Speed Internet

The Business Case for Bonded G.shdsl

Providing just data or just voice services alone is increasingly a commodity business. Service providers have two choices in today's market – offer commodity services and try to survive in a low margin business, or move up the value chain and offer a full range of enhanced services to their customers. Many ILECs, IXCs and Internet Service Providers are attempting to do the latter – by becoming Integrated Communications Providers (ICPs).

What are the access requirements of an ICP?

- **A single connection to the customer.** Provisioning different access lines, and their associated CPE, is a nightmare scenario for an ICP. Indeed, the entire concept of the ICP is to move away from today's multiplicity of voice E1s, Internet Access E1s, ATM private network access E1s, etc.

- **Bandwidth to provide multiple services over a single connection.** For a very small business with limited data and voice traffic, a single H/SDSL or E1 connection may be adequate, but for a larger SME, a service provider will often need 10 Mbps or more – with the ability to increase bandwidth over time by quickly adding new circuits as needed and as the business grows.

- **Quality of Service (QoS) mechanisms.** For most ICPs (or potential ICPs), the QoS and guaranteed bandwidth of ATM services will allow them to provide for both bursty Internet style data transmissions and also high quality voice connections.

Bonded G.shdsl provides exactly these things to the ICP – a new way of providing a reliable, high-speed link to the smaller customer who cannot justify a fibre E3, at greatly reduced prices. It should be remembered, as discussed earlier, that many service providers have access fees totalling up to 40% of their overall expenses. Using Bonded G.shdsl over relatively inexpensive and easily obtained UNEs can bring about a 50% or greater reduction in access costs, while providing a level of service unmatched by E1 or traditional DSL.

Table 2: The Business Case for Bonded G.shdsl

Technology	Bandwidth	Rev/Month	Meets SME Customer Bandwidth Reqmts?	Outside Plant Required	Exchange Capex	Support for ICP Services
E1	2.0 Mbps	€300-€1,500	No	2 UNEs	Medium	Limited - fixed allocation
E1 IMA	4 Mbps	€600-€3,000	No	4 UNEs	High	Limited - fixed allocation
H/SDSL	2.0 Mbps	€300-€1,500	No	1 UNE	Low	Limited (VoDSL)
Bonded G.shdsl	10 Mbps+	€1,000+	Yes	Up to 8 UNEs	Low	Yes
Ethernet over Fibre	10 Mbps+	€6,000+	Yes	Fibre to customer	High	Yes
E3	34 Mbps	€3,000+	Yes	Fibre to customer	High	Yes

Why choose Bonded G.shdsl?

For the service provider, Bonded G.shdsl provides:

- **An easy to provision service that competes with the offerings of new fibre-based service providers.** Without the need to sink capital expenditures into new outside plant facilities, Bonded G.shdsl takes advantage of the installed base of copper plant, not requiring a new installation of fibre

- **A service that can be provided anywhere in the service provider's network.** Unlike fibre-based systems, the copper-based telephone network is already in place and connected to just about all SMEs, allowing a ubiquitous service offering based on Bonded G.shdsl.

- **Ability to leverage existing capital equipment (such as DSLAMs), without a "forklift upgrade".** Most existing DSLAM and other central office equipment can be upgraded to support Bonded G.shdsl with inexpensive, incremental upgrades through the replacement of old or the insertion of new line cards.

- **Limited impact on existing network services.** Because Bonded G.shdsl uses an international standard line code that was designed for low interference, it has very little impact on currently provisioned services like voice, E1, ADSL, etc. So a service provider can begin service introduction without worrying about service degradation or interruption to existing customers.

- **Support for the migration to a fully integrated network.** By offering a native speed 10 Base-T data interface and support for dynamic allocation of voice bandwidth, Bonded G.shdsl solves the last mile issue for service providers, and allows them to offer truly integrated services over a single connection.

For the Small and Medium Sized Business, Bonded G.shdsl allows:

- **Affordable bandwidth to bridge the E1 to E3 Gap.** Services requiring higher bandwidths (like E-commerce and videoconferencing) are no longer out of reach for SMEs, with speeds over five times faster than E1, available for between two and three times the price of E1, and a fraction of the price of E3.

- **A scaleable solution.** Bonded G.shdsl services can be offered at bandwidths between 2.3 and 18 Mbps, and can easily be upgraded within that range by provisioning additional copper pairs.

- **Ubiquitous access.** Fibre services, such as E3 and Ethernet over Fibre, are often difficult, if not impossible to obtain for many SMEs because of the potentially very high cost of installing fibre to their office building. Because Bonded G.shdsl uses ubiquitous copper pairs and provides longer range than most H/SDSL and E1 solutions, it is available to a much wider number of SMEs.

Throughout this paper, the limitations of existing copper and fibre based access methods for Small and Medium Sized businesses have been outlined. Many SMEs have outgrown their existing E1 and DSL connections, but have not grown into E3 – in either bandwidth requirements or ability to pay for such services. Fibre-based Ethernet services would provide the perfect solution for many of these businesses, if only they were available, but in Europe such services are still generally some time away. Using Bonded G.shdsl as a means of leveraging existing copper-based networks and connecting to the fibre backbone is a way for service providers and business to bridge this E-Gap and meet current and future communications needs.

Glossary

10Base-T
A 10 Mbps Ethernet LAN which runs over twisted pair wiring. This network interface was originally designed to run over ordinary twisted pair (telephone wiring) but is now predominantly used with Category 3 or 5 cabling.

Asymmetrical Digital Subscriber Line (ADSL)
BellCore term for delivery of high speed digital information over ordinary copper phone lines. ADSL uses a system of frequency division whereby lower frequency POTS signals are carried to and from the home unaltered while digital signals traverse the phone line at higher frequencies. Asymmetric refers to the fact that the downstream (to the user) channels can be faster than the upstream (to the network) channels by a ratio as high as 20:1 but more usually between 2:1 and 10:1.

Asynchronous Transfer Mode (ATM)
A protocol that packs digital information into 53-byte cells (5-byte header and 48 bytes of payload) that are switched throughout a network over virtual circuits; the relevant standards have been established by the ATM Forum.

Bandwidth
This is a measure of the size or the capacity of a given transmission channel.

Binder Group
Cable pairs are typically arranged under the cable sheath in binder groups. The binder is a spirally wound coloured thread or plastic ribbon used to separate and identify cable pairs by means of colour-coding. The enclosed pair group is called a binder group. The groups are composed of insulated twisted copper pairs that are also twisted within each binder. Typically they are wrapped in 25 or 50 pair bundles although, on leaving the exchange, the binder group may contain 1,000 or even more pairs.

Channel Service Unit/Data Service Unit (CSU/DSU)
A digital interface device that connects end user data communications equipment to the digital local access lines such as E1.

Competitive Local Exchange Carrier (CLEC)
A new telco which, when competition begins, has the less dominant position in the market; the new carrier entering the market, challenging the ILEC (c.f.) market position.

Customer Premises Equipment (CPE)
A wide range of customer premises line-terminating equipment which is connected to the local telecommunications network. This includes telephones, modems, terminals, routers, set top boxes, etc.

Digital Subscriber Line Access Multiplexer (DSLAM)
An exchange based device used to aggregate data traffic from many DSL subscribers into one high-speed signal for hand-off to the data communications network, usually via a fibre optic link.

Downstream
The direction of traffic away from the telephone exchange or DSLAM towards the customer.

E1
This is an ITU/European term for a digital carrier facility used for transmission of data through the telephone network at a transmission rate of 2.048 Mbps. Typically provided over pairs of copper wires.

E3
This is an ITU/European term for a digital carrier facility used for transmission of data through the telephone hierarchy at a transmission rate of 34.368 Mbps. Typically provided over a fibre optic connection in Europe.

Ethernet
A network protocol used to connect devices within a building or campus network at speeds of 10, 100 or 1,000 Mbps. Within the OSI model, Ethernet is defined at layer one (physical) and layer two (data link). Ethernet is based on Carrier Sense Multiple Access/Collision Detection (CSMA/CD).

Exchange
A telephony circuit switch that terminates the local access lines from a particular geographic serving area; a physical building where the local switching equipment is found. xDSL lines running from a subscriber's home usually connect to a DSLAM at their local exchange. The usual term applied within Europe for what in North America is called the Central Office.

Fibre Optic Cable
A transmission medium composed of glass or plastic fibres; pulses of light are emitted from a laser-type source. Fibre optic cabling is the present cabling of choice for all inter-exchange networks, and increasingly for the local exchange loops as well; it is high security, high bandwidth, and takes little conduit space.

G.shdsl
The ITU (International Telecommunications Union) standard for a symmetrical DSL over a single copper pair. This standard provides speeds of up to 2.3 Mbps unchannelised and 2.048 Mbps channelised.

High Bit Rate Digital Subscriber Line (HDSL)
A modulation method that enables T-1 and E-1 signals to be delivered over one to three pairs of copper wire depending on range and speed required. In Europe, HDSL is based on a North American 2B1Q standard with no ETSI or ITU equivalent and so may be considered a proprietary technology in Europe.

H/SDSL
The term used within this paper to describe the older generation of E1 speed DSL services provided using North American standards based technology. This term is used to avoid confusion with the recent ETSI European standard SDSL which is very similar to the popular G.shdsl ITU-T standard.

Incumbent Local Exchange Carrier (ILEC)
A telco or PTT which, when competition begins, holds the dominant position in the market; the original carrier in the market prior to the entry of competition.

Interexchange Carrier (IXC)
An IXC is a long distance telecommunications provider that offers a range of circuit switched, packet-switched, leased line, and enhanced communications services; any company that provides communications services between exchanges on a long haul basis.

Inverse Multiplexing over ATM (IMA)
A technique for combining several access lines of a lower speed (such as E1) into a single virtual connection of a higher speed (for example 2 E1s for a circuit speed of ~4 Mbps).

LMDS (local multipoint distribution system)
A broadband wireless transmission system providing short-range line-of-sight single channel data services from a central mast or distribution point to a number of remote points.

Megabits Per Second (Mbps)
A measure of bandwidth capacity or transmission speed. It stands for a million bits per second.

MMDS (Multi-channel Multi-point Distribution Service)
A broadband wireless transmission system providing short-range line-of-sight multi-channel data services from a central mast or distribution point to a number of remote points; each transmitter/receiver pair may handle multiple simultaneous channels, typically using frequency multiplexing.

OLO
Other Licensed Operator; the term frequently used in the UK and other European countries to refer to new competitive local exchange carriers - CLECs.

POTS
Plain Old Telephone System; the name frequently used for traditional voice telephony.

PTT
Public Telegraph and Telephone company; the term frequently (although outdatedly) used to refer to an incumbent local exchange carrier in Europe.

RJ-45
Eight-pin connector used to attach data transmission devices to standard telephone wiring. Commonly used in 10Base-T connections.

SME
Small and medium enterprise; the term generally used to encompass smaller companies with between 25 and 250 or 500 members of staff. In this paper, the term is considered applicable to those enterprises or businesses with below 500 staff.

Symmetrical Digital Subscriber Line (SDSL)
In Europe, this is beginning to refer to an ETSI standard symmetrical DSL line; this standard uses a different transmission technology to ITU G.shdsl and is not interoperable with it. However, it is also used as a generic term for a DSL connection that provides the same upstream and downstream transmission rates. In the US, most systems called “SDSL” systems are proprietary and utilise a 2B1Q encoding scheme; not to be confused with the ETSI SDSL.

Telco
A generic term for the local telephone company or PTT in a given area.

Unbundled Network Element (UNE)
An ILEC or incumbent-owned pair of copper wires made available to competitive providers under local loop unbundling provisions.

Upstream
The traffic flow from the customer to the telephone exchange.