The Alcatel Experience of DSL Deployment

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Incumbent telcos desire to make the optimum use of their existing copper pair networks in order to deliver the new services required by their customers. This enables the incumbent telcos to compete with new operators who use alternative technologies, without incurring the very high costs of building new infrastructure. The technologies used by the new operators include cable TV systems, which can be extended to offer not only broadcast TV, but also telephony, fast internet access and other data services, as well as video on demand. Other competing technologies are satellite, which can be combined with a telephony back channel to provide a limited interactive service, radio microwave distribution, and all fibre systems. However, the price performance combination of the DSL technologies is so attractive that even new operators are increasingly making use of them.

There is now a range of different DSL technologies available for high speed transmission over copper, which are appropriate to the requirements of different customers. These include HDSL and SDSL for symmetric services mainly to business customers, ADSL for asymmetric services to residential and SOHO customers, and VDSL for very high-rate symmetric or asymmetric services to business or residential customers. VDSL has a relatively short range, and is thus often operated from street cabinets, although operation from exchange buildings is sometimes done. HDSL, SDSL, and ADSL can be operated from exchange buildings or street cabinets as appropriate. This paper outlines the range Alcatel DSL products, and the experience of their deployment.

Alcatel experience of DSL began in 1989 with field trials of 2B1Q transmission. The FONTAS product (later known as ASMLX) resulted in 1990, and was widely deployed in Germany (about 12,000 systems). FONTAS/ASMLX was a uni-directional product, requiring separate pairs for each direction of transmission.

Later developments utilised bi-directional transmission on each pair. Two pairs were used in the US, but sometimes three in Europe due to the requirement for 2 Mbit/s rather than 1.5 Mbit/s. However, in some European countries use of three pairs was difficult due to the cable being quad based, and all more recent European systems use two pairs only. Rate adaptive (nx64kbit/s) versions are available to provide a trade-off between data-rate and range. Alcatel 1512 HDSL is deployed world-wide (about 130,000 systems).

Enhanced HDSL began with ANSI HDSL-2 in the US, a single pair system for a fixed rate of 1.5 Mbit/s (approved for publication in December 1999). A rate-adaptive version of the standard is under development in ITU-T, named SHDSL. In Europe ETSI are working to define ETSI-SDSL, which will be a single pair standard, closely aligned with ITU-SHDSL, including rate adaptation and in-band ISDN amongst other features. Alcatel Line-Runner products are available to these standards.

Alcatel field trials of ADSL were followed by the first significant deployment in Singapore in 1997. At present Alcatel have about 50% of the DSLAM market, with over 1.3 million lines installed world-wide. ADSL line cards are also offered in the Litespan 2000 range in the USA, and will be offered in the Litespan 1540 range in Europe and elsewhere. In addition, the Alcatel ADSL chip-set is used in the products of many other manufacturers. Alcatel DSLAMs and chip sets use the standardised DMT line code.

All Alcatel ADSL DSLAMs and customer end modems are in fact multi-standard, so that they will operate with not only with full-rate ADSL (G.DMT), but also with reduced rate ADSL (G.Lite), as well as with ANSI TI413-1998. Interoperability between equipment from the various manufacturers of ADSL is of importance, in particular where the customer purchases his own modem and the operator wishes to avoid a truck-roll. Alcatel believe that in this case it is often better to use full rate ADSL with a distributed splitter, rather than G.Lite. Alcatel organise comprehensive testing at our interoperability laboratories in Antwerp, the University of New Hampshire in the US, and in Taiwan.

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VDSL is currently under development by Alcatel. Alcatel believe that DMT is the most appropriate line code for VDSL, for reasons of performance, flexibility, compatibility with other service in the same cable and with wireless communications systems, future proofing, and interoperability with ADSL. The DMT TDD R1.0 system was demonstrated at Geneva in 1999, and is available for laboratory and field trials. The DMT FDD R2.0 product is currently under development, and this will feature a high degree of integration as well as low power. Interoperability between different manufacturers of VDSL is also of importance.

The deployment of the various DSL technologies has raised a number of questions, many concerned with the interaction between these technologies.

Multiple systems of the same DSL technology interfere with each other when operated in the same physical cable. For HDSL and other echo-cancelled systems the main limitation is Near End Cross Talk (NEXT), and the worst case effect of this can be predicted by using the ETSI noise model.

There is also interference between different DSL technologies operated in the same physical cable. Again the main component is NEXT, but this could be eliminated if it could be ensured that the up and downstream transmisison frequency bands did not. However, this is not done, and for example, the main limitation on ADSL in the UK is probably is NEXT from HDSL systems. In the US repeatered T1 systems may be of more concern.

Some Telcos have a requirement to provide the same customer with both ISDN and ADSL. In this case the ADSL frequency range can be altered so that it does not overlap with that of ISDN. However, there is then a reduced bit-rate, and the ISDN (G.DMT Annexe B) and normal versions of ADSL (G.DMT Annexe A) would interfere with each other if deployed in the same cable. Countries with a high IDSN penetration, for example Germany, do use the ISDN version. An alternative approach would be to carry the equivalent of the ISDN traffic within the ADSL bit-stream itself.

External interference also plays a part, but the DMT standard adopted for ADSL is often an effective solution. Carrier tones subject to severe interference, for example from broadcast radio or from radio amateurs, can simply not be used to carry data. Interference can also occur from non-radio systems, for example the Home Phone Networking Alliance (HPNA) systems for data distribution within the home. Signals from HPNA systems will be transmitted out into the telephony access cables, and cross talk will then cause interference with DSL signals in other pairs in the cable. The frequencies used by HPNA are such that, without precautions, VDSL would be the most affected. To avoid such interference, the HPNA signals in-house could be blocked at the entrance of the home by appropriate filters to avoid pollution of the outside loop plant. Alternatively, careful frequency planning for VDSL, possibly in combination with HPNA cross-talk cancellation techniques, can solve the problem.

DSL can also cause interference with radio systems. Again, the use of DMT provides the possibility of not using particular tones likely to cause interference. In the UK the Radio Communications Agency have issued a draft proposal for radio emissions, and a similar proposal has been made in Germany by Reg TP. The radio emissions are increased if the pair is unbalanced. There may thus be increased radio emissions when the DSL signals traverse the customer's home wiring, which may not be adequately balanced.

For all DSL systems there is a trade-off of range and bit-rate. If service is offered at fixed bit-rates then there are customers who will be unable to receive service. This problem can be mitigated by the use of rate adaptive DSL systems. On training up after connection the DSL system will determine the bit-rate that it can achieve with the required margin. A remaining issue is that subsequently to installation the performance may be degraded because of additional interference, from newly installed DSL systems or from external sources of interference. In this case the bit-rate available to the customer will be reduced.

There are obviously circumstances where rate adaptive systems are not appropriate, such as the use of ADSL for video on demand, where a minimum bit-rate of about 2 Mbit/s is normally required. In this case a prediction is required of those customers in range of the service, and this can be made from a line test of loop resistance, or from a calculation based on the cable details.

In the case of HDSL the standards do not provide for interoperability, that is an exchange unit from one manufacturer will not work with a customer premises unit from a different manufacturer. For ADSL it is the intention that equipment from different manufacturers should be mixed, and to this end trials have been held by Alcatel and others. In some cases a feature may be available from one manufacture and not the other, in which case a lowest common denominator approach has to be taken,

As noted above, interoperability is particularly vital where the operator wishes to avoid a truck-roll (distributed splitter full-rate ADSL or G.Lite, or splitterless G.Lite). If the customer is free to purchase his equipment from whichever manufacturer he chooses, then the telecoms operator will not know the characteristics of the customer end equipment, and there may be an impact on performance. The use of distributed splitters rather than a splitterless system, will usually provide improved performance (a high pass filter is installed in the DSL modem connection, and a low pass filter in each phone connection). It should be possible for the customer to install these distributed filters himself, and thus a truck-roll should still not be required. In this case full rate ADSL may be used instead of G.Lite.

The availability of DSL raises a large number of marketing issues, which are not the prime concern of this paper. These include service cannibalisation, that is should an incumbent operator introduce new DSL based services even if these lead to a reduction in revenue from his existing services, or should he wait until a competitive operator is ready to strike? DSL connection to the Internet offers the possibility to replace time based charging, but should this be by usage based or flat rate charging? Note also that the service from ADSL lines will not be the same for all customers, unless a very low bit-rate is specified. The concept of universal service may thus be undermined in those countries in which it is usual.