The Trouble with DSL

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More and more Internet providers are now turning to Digital Subscriber Line, or DSL, as a way of providing high speed access to the Internet. Large scale rollouts of small business and residential services are happening in many parts of the globe including North America, Europe and Asia.

In many ways DSL represents a remarkable recycling of old telephone infrastructure, and a radical departure from the process of continual refinement of modems in an attempt to jam more bits per second down the voice line. DSL operates on the premise that a twisted pair of copper wire behaves in a similar way to a shielded coaxial cable, and rather than limiting the analogue signal to the 3Khz band used for voice, DSL uses a wider band of higher frequencies to carry the digital signal. By carefully spreading the power across a broad range of frequencies the level of crosstalk between one copper pair any other pair in a trunk bundle can be limited to a manageable level. The results are by any standards quite impressive, and even on relatively long copper loops of some 8 - 10 miles, speeds of up to 1.5Mbps can be supported. If the copper loop is shorter, even higher speeds can be supported, and DSL services that carry up to 6Mbps of downstream traffic to the customer can be provided in a DSL network. The most common form of deployment is Asymmetric DSL, or ADSL, where the return path back to from the customer to the central office is a lower bandwidth, commonly 256Kbps. This limitation is again largely based on the considerations of crosstalk in the large copper bundles close to the central office.

DSL presents a number of significant benefits to both the customer and to the service provider. Not only can DSL provide high bandwidth services, but it also unloads large volumes of modem-based call traffic from the PSTN, and relieves, to some extent, the emerging demands on the copper network for second and further PSTN lines to residences. More importantly, DSL allows the Internet to switch from an intermittent access model to an 'always on' model, where the Internet service is always available and always connected. There is no concept of an "access call" in DSL, and like reticulation of water and electricity, and in the same way that dial tone is always present when you lift the phone handset, DSL can present itself in a manner that the Internet is available whenever you power up your PC.

The advantages of DSL do not stop there. Increasingly, residences have more than one PC, and, in the future, residences may have multiple Internet access devices that bear little resemblance to a PC. While the concept of an Internet-connected washing machine may seem a little far-fetched today, we have to remember that silicon is a volume industry and, in sufficient volume, silicon chips can be very cheap indeed. This model of a collection of Internet devices at home, or in the office of a small business, interconnected by a home wireless LAN is one which appears to have some force and DSL fits naturally here. In this model its the LAN itself which connects to the DSL service, in the same way that a house wiring system connects to the external mains supply.

So with all these aspects in favour of DSL, what’s wrong with this model? Well its not the home LAN, nor the copper loop that’s the problem. The problems start at the central office where all the cooper loops terminate. The ISP industry has been shaped by modem-based access. Using a local access call you can obtain Internet access services from a large range of access providers, and the access provider industry is one which has a wide diversity of players. In this industry model the copper loop provider is neutral with respect to the customer's choice of ISP. There is strong pressure, often backed by regulatory conditions, to reproduce this model in DSL. The trouble with DSL is that its no longer modems and data calls that are overlays across the PSTN network. The trouble with DSL is that reproducing this model calls for new engineering approaches in the access network to implement this model of competition in Internet access. This model requires the copper loop provider to open up competitive access to this copper loop network, allowing any provider to have equal access to DSL customers.

Another aspect of modem-based access is that the chosen ISP not only provides customer care and billing services, the ISP also provides data transit services to the customer. Your choice of ISP dictates the way in which your IP traffic is passed through the network. The conditions of a neutral DSL loop appear to also imply that the DSL system should pass all the customer's traffic to the chosen service provider. And its here that the problems start with DSL. In the modem access model its the PSTN itself which provides the necessary switching capability to pass the data traffic back from the customer to the ISP. But DSL operates at speeds well beyond the 64Kbps circuit switching capacity of the PSTN, so some other solution is necessary to connect the customer to the ISP. One potential model is to require the service provider to build their own high speed access network, so that the service provider must install equipment alongside every DSL Access Modem (DSLAM) in each central office of the copper access network. Such an approach represents a significant barrier to entry for an ISP in terms of equipment and a likely massive duplication of fibre access networks for each provider to independently connect to each central office. The more common approach to neutral DSL service is to use a common high speed access network that extends to every DSLAM, and overlay across this common network a number of logical networks, one for each ISP, allowing the ISP to logically connect to a large number of DSLAMs via a single high speed connection to the access network. The modem model further intrudes by demanding that the logical connection of a customer to a service provider is an on-demand one, and that a customer should be able to switch providers without requiring the DSL access network to be reconfigured to the customer's requirements. In other words the logical connection from the customer to the provider is to be provided as a megabit on-demand call.

While this may sound fine, lets go back and look at some of the numbers we're talking about here. A single DSLAM may have hundreds of individual DSL services connected to it, and a metro region may itself have hundreds, of not thousands of DSLAMS. If each individual service is just 1Mbps, then the access network has to be engineered to support traffic levels of gigabits per second. And overlayed across this gigabit network is the requirement to establish on-demand logical circuits of megabit capacity. Here's where the model starts to break down. There is no level 2 switching technology that scales to this level of requirement, both in the size of each individual virtual circuit and the sheer number of virtual circuits that may be active at any point in time. While the answer of "just use IP" is tempting, the requirement that all the customer's traffic must pass through the access network back to the selected provider mandates a level 2-based approach rather than an IP solution.

Many DSL operators have turned to ATM as the level 2 technology to provide the logical connection between the customer and the ISP. This is often significant compromise in both total speed and number of virtual circuits. To manage the proliferation of virtual circuits the DSL access provider often uses some form of logical circuit aggregator in the access network, where all the per-customer virtual circuits for an ISP are aggregated into a single virtual circuit between the aggregator and the ISP. All engineering is a compromise of one form or another, and in this case the solution exposes a critical point of failure in the network, as failure of the aggregation unit causes failure of the DSL service. In addition the ATM logical circuit does not extend from the customer to the ISP. It extends only from the customer's DSL modem to the aggregation unit. To create the end-to-end logical access service the model typically uses the PPP transport protocol, starting as PPoE (PPP over Ethernet) on the home LAN, which is mapped to PPoA (PPP over ATM) in the DSL modem. Now the modem service is precisely reproduced. The home LAN has disappeared, and the service model is one that connects a single PC to a selected ISP for the duration of an access "call".

Where we are today with DSL is that the effort to reproduce the characteristics and industry structure of modem-based Internet access is compromising some of the potential benefits of DSL. DSL services are once more based on an access call to a provider, connecting a single PC directly to the chosen ISP. "Always on home LANs" are no longer a feature of the service, nor can sustained high speed be reliably provided to each and every DSL customer. Traffic between two customers of the same ISP passes across the common ATM access network twice, even when both customers are located on the same DLSAM.

It doesn't have to be like this. One potential approach is to replace the ATM-based common access network with an MPLS-based peer VPN access network. The connection of a customer to a selected ISP would configure the DSL circuit as an access circuit into the ISP's VPN. This model has some compelling features, and some new challenges. Traffic between two customers of the same provider need not necessarily be passed all the way back to the provider. While a traditional hub and spoke VPN configuration can be supported, it is also possible to support a fully meshed VPN, allowing cross-customer traffic to take the shortest path through the access network. The challenge presented by this fully meshed VPN access model is one of accounting for the customer traffic when the traffic itself never enters the ISP's network. The features of this approach include the elimination of the virtual circuit aggregator as a single point of failure, and the use of existing high speed IP technologies to provide an access network of the scale of gigabits per second, allowing the DSL system to operate at its full potential.

As always, one can go further with such models of bringing IP closer to the DSLAM. One competitive model of phone service is one where the origin of dial tone, and the way in which local calls are routed through the phone network, are unaltered when the customer switches phone providers. The competitive providers offer customer care and billing services, but do not switch the individual calls through their own networks. It is possible to think of a model of DSL that has similar properties, where the base IP service is common to all customers, and provider selection implies an administrative change of the service provider without a change in the way in which traffic is passed through the network.

Its likely that DSL will, over time, largely replace the model of dial-up Internet access, and to realize the full potential of the speed and service models that DSL can facilitate, it may be necessary to look at DSL differently. Competitive access is an important aspect of the deregulated communications market, but making DSL look precisely like a higher speed modem access system does not allow DSL to provide its full potential as a mass market high speed Internet access service that alters the access model from novelty to utility.