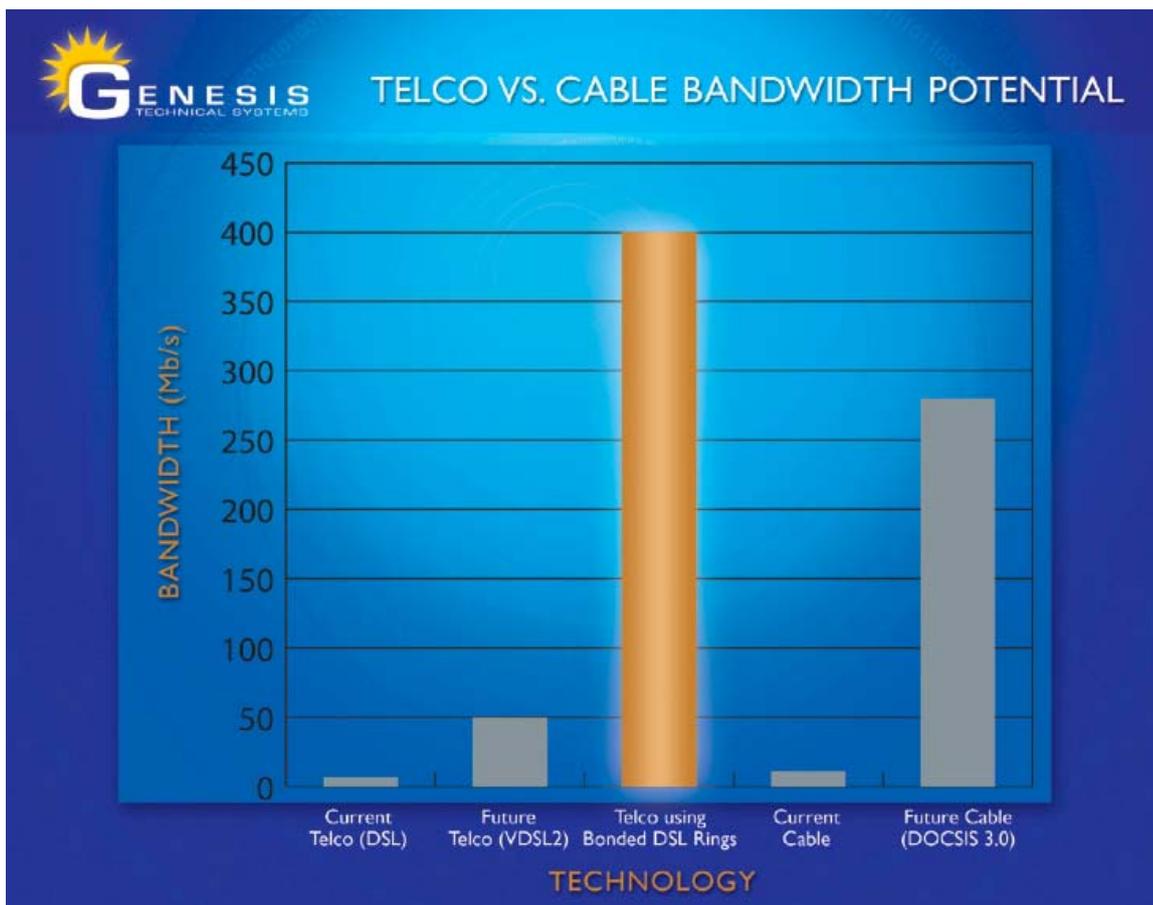


DSL Rings[®] White Paper

INTRODUCTION

DSL Rings[®] (DSL_R) is a patent-pending access technology that re-uses existing copper telephone cabling to provide bandwidth of up to 400 Mb/s with Quality of Service (QoS) and Efficient Multicast. Unlike fibre- or cable-based alternatives *DSL_R* can also provide E911/E999 service when the power is out.



ANALYSIS

Telecom Service Providers are being forced to examine their network's last mile technology due to a number of factors, including VoIP-based competition from cable providers; and whilst video offerings have been in their plans for many years they have had limited success.

Current implementations of copper telephone networks cannot support the bandwidth necessary to offer a realistic streaming Standard Definition Video (SDV) service; even with MPEG4 compression (requires approximately 4 Mb/s guaranteed/channel). VDSL2 technology has increased the bandwidth-carrying capability of the wires significantly but, as with all DSL-based technologies, is highly distance-from-the-DSLAM sensitive (see Figure 2).

Other technological alternatives exist but they all require significant financial investment to upgrade the physical cabling, generally to fibre-based technologies. The business case for these deployments varies from situation-to-situation but certainly does not apply to all cases.

Any additional fibre deployment in the access network, other than for green field situations, cannibalises the existing copper wire infrastructure to varying degrees. FTTP/H replaces the entire copper wire infrastructure; and FTTC & FTTN requires replacement of a substantial amount of existing, invested in, revenue-generating infrastructure.

Wireless-based network upgrades, whilst being relatively inexpensive compared to fibre, often require spectrum licensing, have physical security challenges, and peak bandwidth difficulties. They are also subject to disruption, location and reception issues, and they lower the barrier to market entry as competing carriers can deploy such solutions almost as easily as incumbents.

Both wireless-based and fibre-based bandwidth enhancement options result in cannibalising the existing copper wire that is the single most valuable asset to the telcos.

To summarise, these developments don't meet market demands, require disproportionate investment, or reduce competitive differentiation. One alternative is shared bandwidth.

SHARED BANDWIDTH

Shared network bandwidth has always been a part of our telecom experience. Statistical multiplexing is used by every carrier on earth though the ratios vary from carrier-to-carrier and location-to-location.

Cable networks are entirely based on bandwidth sharing via a ‘bussed’ model (i.e., one common physical wire that everyone connects to). This means that everyone on that network segment can see (if they have sufficient equipment and understanding) what everyone else is doing on that cable.

The point is that bandwidth is currently a shared resource in our networks, it has always been a shared resource (at varying levels) and there are economic benefits to retaining a shared bandwidth model.

“Bonding” enables a significant increase in bandwidth at virtually every distance provided, as long as there are pairs available for the purpose. Bonding is when the original high bandwidth signal is split into several pieces and then each uses several different physical pairs as a single transmission link. This process is specified under the moniker G.Bond (ITU – G.998.1, 2, 3).

The difficulty of applying bonding by itself to the existing cable plant is that there are generally between 2 and 4 pairs going into each residence. If the current standard of 4 Mb/s is used, this yields a maximum of 16 Mb/s available to each house (this bandwidth is still shared once it hits the DSLAM). Typically there are only 2 pairs in residences and the maximum bandwidth would be 8 Mb/s. This is still considered to be very tight for video transmission, even with MPEG4 compression (which is not very common) as the bandwidth and latency needs to be guaranteed.

DISTANCE REDUCTION

A frequently used technique to reduce the transmission distance seen by electrical (and optical) signals is to regenerate the signal somewhere along the path. This has the effect of resetting the transmission distance to zero and starting again. From the perspective of the telecom network, simply regenerating DSL signals serves little purpose and provides no real value-add. For example, to maintain ‘maximum’ VDSL2 bandwidth (at a 500 ft distance) would require digging up all the large >1000-pair cables every 500 ft to deploy a regenerator; not to mention all the smaller cables as well.

A solution used in the optical domain was to turn the regenerator site into an Add-Drop Multiplexer (ADM). This allowed the main signal to be completely regenerated, and at the same time, add and drop traffic at that point. The ADM configuration was later modified so that the ADMs could be arranged in closed rings so that all bandwidth was available to all sites if they needed it. Previously it had been put in straight lines and wasted large amounts of bandwidth as the first position in the line had access to the whole bandwidth but rarely needed it, the next position typically didn’t add too much on top of the first, and so on. Gateway nodes were inserted in the ring so that connections to the main network were maintained. This configuration describes a ‘collector’ ring and is now widely used in metro-level optical networks.

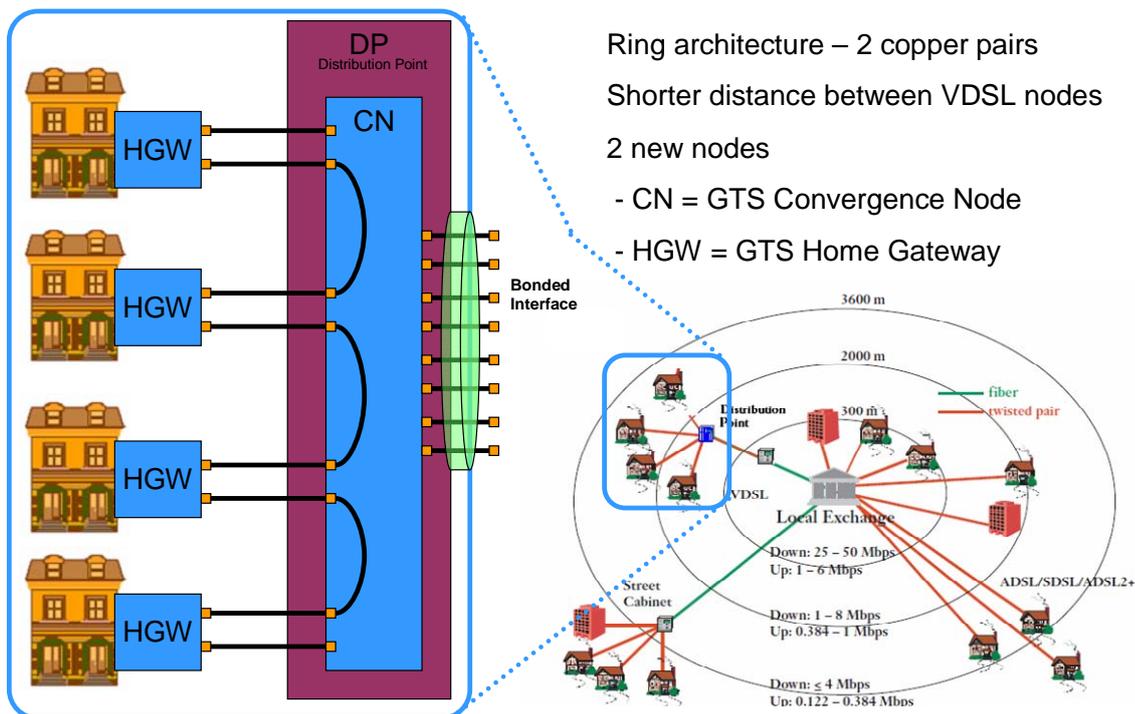
APPLICATION TO CURRENT 'TREE AND BRANCH' COPPER TELEPHONE NETWORKS

DSL Rings is a patent-pending network architecture developed by Genesis Technical Systems Corp. The architecture provides most opportunity in the current 'tree and branch' network if the portion of the network from the Central Office (CO), or Exchange, to the last Pedestal (Distribution Point – DP) is bonded.

Refer to Figure 1 - for a graphical description of the architecture. Note that the links between the houses are implemented via passive jumper wires that do not come back to the Convergence Node (CN). In this way, a single CN design can efficiently manage 2-16 houses in a given ring. Genesis suggests a maximum of 16 houses in the ring due to the delay introduced by transiting each node to get back to the CO; however RPR has an upper limit of 255 nodes in a ring.

DSL RINGS

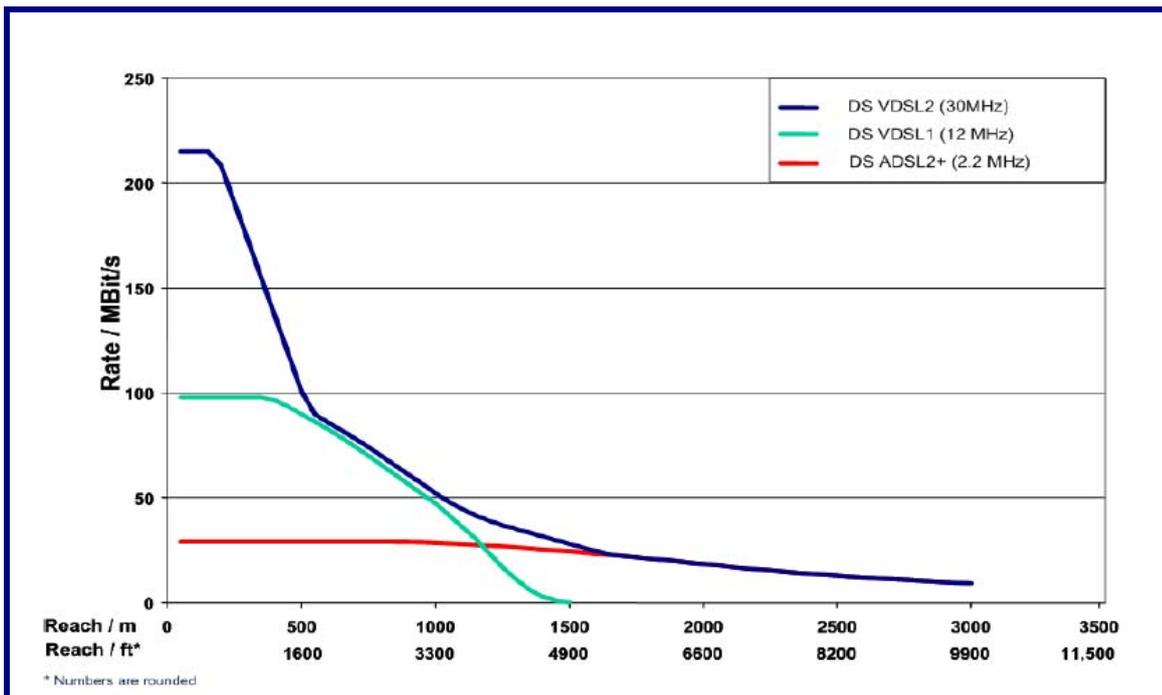
Figure 1 - Current vs. DSL Rings Architecture



Bonded pairs are used to obtain maximum bandwidth from the CO to the pedestal (DP). The Convergence Node, which is environmentally hardened and powered via the copper wire from the CO, terminates the bonded signals and acts as the gateway node for the subscriber 'collector' ring.

As each node in the ring is a full ADM, based on VDSL2, the DSL transmission bandwidth starts at zero again on each individual hop. In most cases the hops back to the pedestal and then to the neighbour's house are less than 250 meters (<750ft). VDSL2 bandwidth at this distance is about 200 Mb/s (depending on VDSL2 chipset manufacturer's specifications and the quality of the cable). Please refer to Figure 2 - DSL Rate Curves for comparisons.

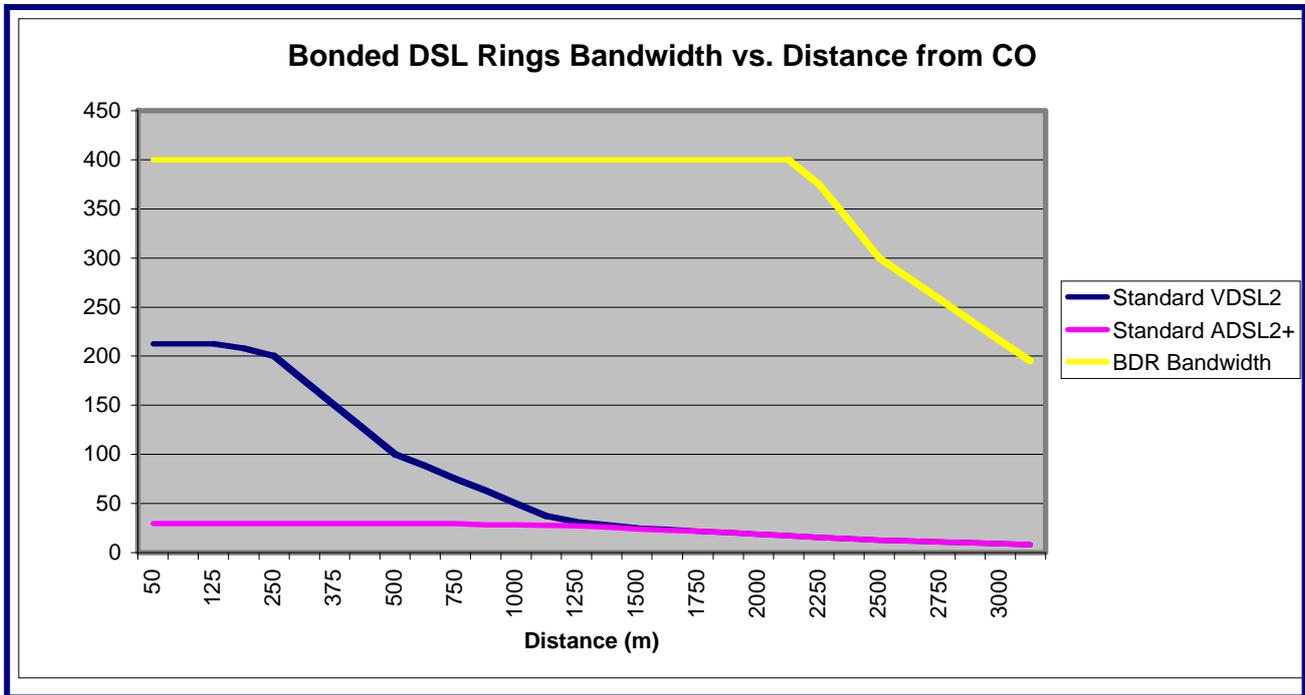
Figure 2 - DSL Rate Curves



Source: Infineon: "Future Proof Telecommunications Networks with VDSL2" by Stephan Wimoesterer, Product Marketing Manager, VDSL2; July 2005.

With *DSL Rings* there are two paths into and out of each house, each with the potential of carrying up to 200 Mb/s. Therefore the bandwidth potential for this scenario is up to 400 Mb/s (200 Mb/s Eastbound and 200 Mb/s Westbound) depending on the number of bonded pairs and the actual distance from the DSLAM to the pedestal. The greater the number of subscribers on the ring, the greater the bandwidth pool available due to the greater number of pairs available for bonding from the pedestal to the CO.

Figure 3 – Throughput vs. Distance provides a rate comparison of standard VDSL2 with *DSL Rings* using various numbers of subscribers.



RPR PROTOCOL

DSL Rings technology is based on the RPR protocol that provides multiple advantages. The technology enables a fail-safe in that, if a single pair is cut, the traffic goes in the opposite direction around the ring to get to the network gateway node. This is extremely useful for maintenance purposes, as well as for adding and removing nodes (houses) to/from the ring. This allows for a deployment business case based on customer demand which eliminates the sunken investment in a ‘build it and they will come’-type approach. RPR also provides built in Quality of Service (QoS) for traffic differentiation and managed services as well as an Efficient Multicast (EM) capability that significantly reduces overall ring bandwidth requirements for multicast/broadcast video.

RURAL AREA COVERAGE

Within the *DSL* architecture the bonded link to the CO/Exchange, which is typically a binder group (20 – 25 pairs depending on the telco), is terminated at the pedestal where a ring is initiated. In rural and suburban areas the pedestals are often connected together by the same

physical binder cable. The cable comes out, drops a few pairs to service a few homes, progresses down the street, drops a few more pairs, etc. The pairs that were 'dropped' at the first pedestal are still physically in the cable bundle that progresses down the street to the next pedestal.

DSL Rings provides the capability to, not only terminate the bonded link from the CO but to also, initiate another bonded link towards another pedestal down the road. It is thus possible for *DSL R* to provide up to 400 Mb/s bandwidth to homes that are greater than 7 km from the CO/Exchange, using the existing copper wire infrastructure, depending on the distances from the CO to the first pedestal and between pedestals.

Figure 3: Typical Rural Telephony Deployment

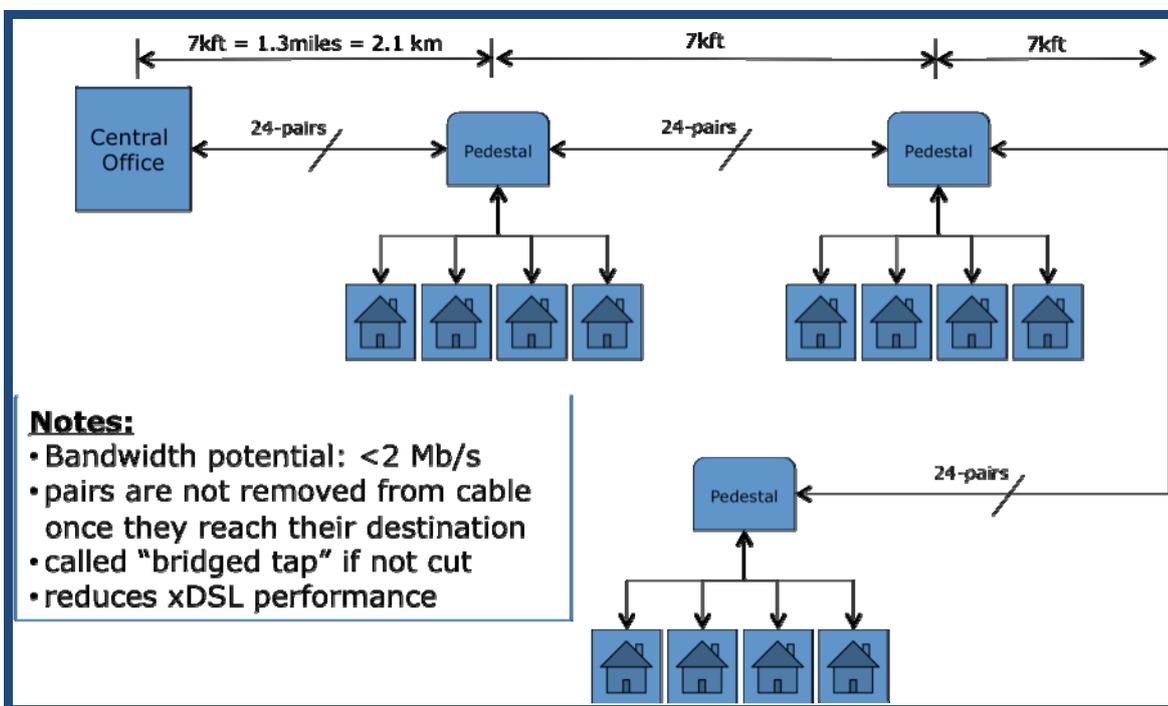
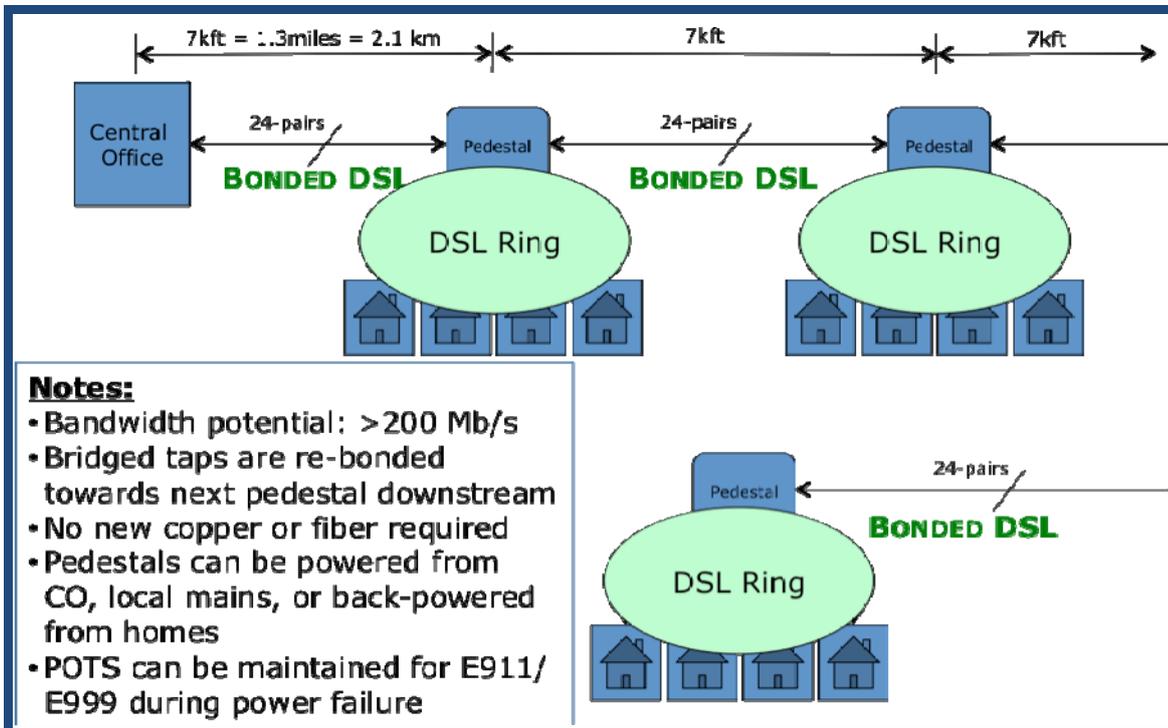


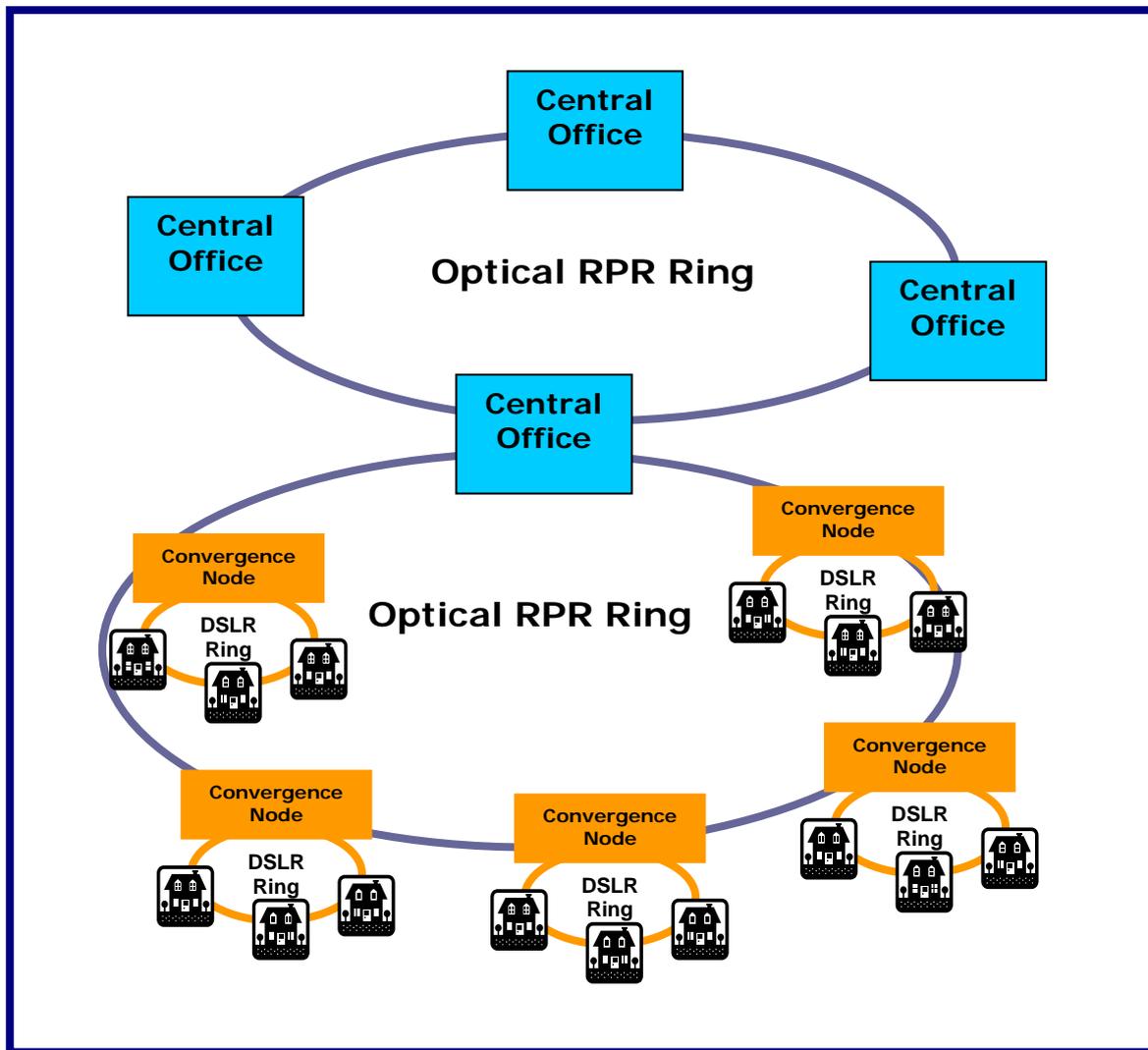
Figure 4: DSLR Rural Implementation



NETWORK EVOLUTION

Figure 5 depicts an evolution of the current network based on an expansion of the metro architecture into the last mile using hierarchical optical RPR rings deployed to the pedestal with the Genesis *DSL Rings* as the last 100m access technology.

Figure 5 – Evolution of the Network



The above architecture eliminates layers of transmission equipment (e.g.: DSLAMs) and the need for DSL Bonding thereby standardising the overall network topology and technology. Layer 2 RPR extended to the CPE provides a clean, efficient and fault tolerant packet handoff between hierarchical ring layers. RPR also simplifies device management, supports QoS and EM capability,

which can be used for live broadcast events and CPE software upgrades. The copper telephone line can be used to supply electrical power to the convergence nodes and CPE devices.

DSLAM BYPASS

The *DSL*R bonded backhaul link can be logically considered to be a single communications channel of relatively significant bandwidth. Accordingly *DSL*R blades could be produced that would fit directly into Edge Routers, Broadband Remote Access Servers (BRAS's) or Multi-Service Access Nodes (MSANs) thereby bypassing the Central Office DSLAM altogether.