

Actelis
Networks

XLR8

Accelerating IP DSLAM Backhaul With Ethernet in the First Mile Solutions

A Design Guideline and Best Practices Document



DSLAM
Backhaul





Accelerating IP DSLAM Backhaul With Ethernet in the First Mile Solutions

A Design Guideline and Best Practices Document by Actelis Networks® Inc.



“Actelis is riding the Ethernet wave, earning the #1 market share by selling EFM bonded-copper products to service providers around the world for use in applications such as business connection, DSLAM backhaul, cell site backhaul, and city traffic control.”

*Michael Howard, Principal Analyst and Co-founder
Infonetics Research*

Learn more @ Actelis.com

Executive Summary

The proliferation of applications like YouTube in the consumer segment and video conferencing and VoIP in the enterprise segment has created an explosion in the bandwidth demand that networks must provide. The growth impacts not only the “last mile” or “first mile,” but also the middle mile and core network. The last mile or first mile refer to the access network linking subscribers in their homes or businesses with the carrier’s network and runs over dedicated, highly resilient circuits. The middle mile or backhaul network refer to the part of the access network linking the edge of the network to the core network. The growth in customer demand is driving the need for additional capacity in every part of the carrier’s network. A majority of the world’s carriers have adequate capacity in the core of the network but require massive upgrades in the backhaul and last mile networks. This application note focuses solutions that provide adequate capacity for the middle mile or backhaul network.

While the limited bandwidth supported by legacy solutions, like T1s (and T1 IMA groups), are inadequate to meet the growth in demand, fiber continues to be too expensive or not feasible. In order to stay competitive, carriers require a cost-effective alternative to connect IP DSLAMs and remote IP DSLAMs to their core network that will deliver broadband services to even the most remote areas. Actelis Networks’ solution, based on our award-winning and patented *EFMplus*[™] technology, combined with our Ethernet in the First Mile (EFM) high-rate repeaters, provides the ideal solution. This application note provides some insight into the challenges in backhauling traffic from IP DSLAMs and best practices for carriers using Actelis to provide a cost-effective and manageable solution for higher capacity in the backhaul network. Actelis’ *EFMplus* technology enables delivery of up to 100Mbps of symmetrical bandwidth and reaches beyond 30km/100Kft. All of the scenarios described have been successfully tested and deployed by more than 200 service providers across 40 countries, making Actelis Networks the leading global supplier of Ethernet over bonded-copper solutions, as recognized and named by industry analysts Frost & Sullivan and Infonetics Research.

Understanding Customer Needs and Market Forces

Telecommunication service providers are being threatened by cable competitors. To counter the competition and meet the insatiable bandwidth needs of their customer base, service providers are upgrading all parts of their network. One of the key elements that sit between the last mile and core of the network is the DSLAM. Traditional copper-fed DSLAMs utilize T1 circuits (or T1 IMA groups), each of

which has a maximum bandwidth capacity of 1.5Mbps per link and, therefore, cannot cost effectively meet the bandwidth required to serve today's customers.

In order to increase network capacity, one option carriers are considering is to lay fiber to every DSLAM. This option meets one of the core requirements: providing bandwidth. However, it does not always meet the threshold of providing bandwidth cost effectively or quickly. In areas with high population density, such an approach might be cost justified. In remote locations and locations with lower population densities, the time required to lay fiber and the associated cost of laying fiber cannot be justified. The same logic applies to locations where the terrain is not conducive to laying new fiber and there are existing good quality copper pairs.

Any solution implemented by the carriers must provide a combination of higher *Rate* (bandwidth), *Reach* (ability to provide service anywhere and everywhere) and *Reliability*—what Actelis refers to as the 3 R's of EFM™—critical to support the next generation of bandwidth rich applications.

Accelerating ROI

Rather than incurring long time frames and the exorbitant costs of laying new fiber, a more cost-effective solution for increasing DSLAM backhaul bandwidth is to leverage the existing copper facilities by using Actelis' Ethernet First Mile (EFM) access products.

The rapid deployment of Ethernet services using EFM (or Ethernet over copper) provides the ability to cost effectively migrate from legacy T1 services and deliver exponentially higher bandwidth to remote cabinets and DSLAMs, all with existing copper. As more and more customers demand higher and more reliable HSI (High Speed Internet) connections, the use of Ethernet over copper provides the only viable solution. Actelis' solutions enable delivery of standard-based symmetrical Ethernet service of 15Mbps over a single copper pair, compared to a single copper pair for a T1 circuit running at less than 1Mbps. This solution allows delivery of resilient (redundant), robust service at significantly lower dollar per bit, compared to legacy solutions. With copper, service providers can leverage their existing infrastructure and, subsequently, the resulting ROI will be months instead of years. Better yet, they can do this while providing data rates that will meet the current and future requirements of their customers.

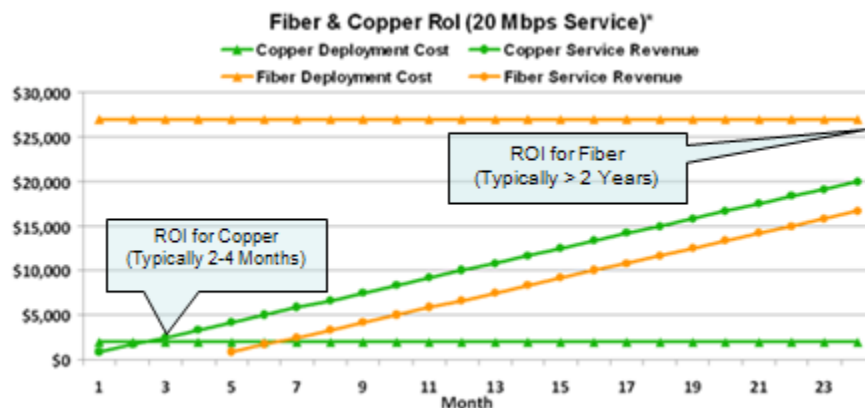


Figure 1: Comparing Cost and ROI for Fiber and Copper

Solution Characteristics

As specified above, the solution chosen to meet the needs of the backhaul network must provide the *Rate, Reach and Reliability* that operators require to meet customer demand. These, along with other critical components of an ideal solution for DSLAM backhaul, are explained below.

Higher Rates: The diagram below (Figure 2: Comparing Bandwidth of T1 and EFM) compares the bandwidth available using legacy T1s with bonded Ethernet over copper. As illustrated, the bandwidth delivered by Ethernet over copper, using the Actelis' solution, can be ten times (10x) that from legacy T1.



The Actelis XR239 EFM Repeater

As previously mentioned, Actelis' award-winning EFM*plus* technology delivers up to 15Mbps per copper pair. This throughput can be achieved through Actelis' variety of aggregation platforms or in the single point-to-point mode with our ML600 series of Ethernet access devices. Where high rates are required for the backhaul, either product can provide rates in excess of 60Mbps over 8 pairs at 4,000 feet of 24-gauge cable. Utilizing Actelis XR239SE EFM repeaters, throughputs can be beyond 40Mbps at 34,000 feet. For more detailed information on performance, please refer to your Actelis Planning Guide.

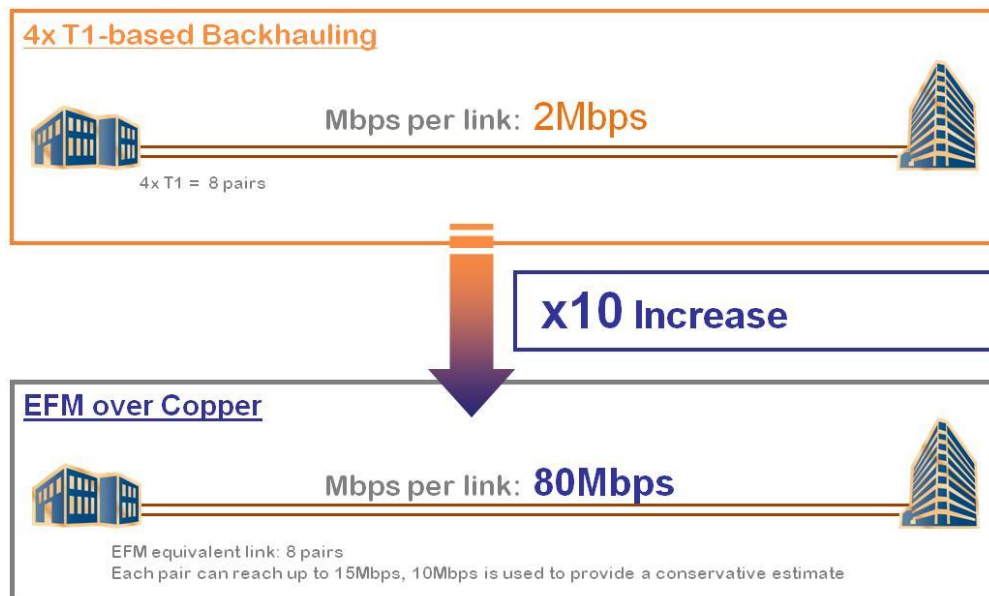


Figure 2: Comparing Bandwidth of T1 and EFM

Supporting Advanced Services: Actelis' products allow traffic prioritization with full support for Quality of Service (QoS) at the customer premises (CPE), and at the central office (CO). Services can be classified by different criteria and mapped into 4 or 8 priority queues depending on the type of traffic and the specific equipment deployed. Support for QoS is critical to ensuring that the access segment is no longer the bottleneck in the network. Prioritizing services at the edge ensures the higher prioritized traffic is forwarded before lower priority traffic during times of congestion to guarantee proper traffic management required to meet the SLAs.

Greater Reliability and Resiliency: The ability to bond multiple copper pairs to create a bonded Ethernet over copper link allows for a more reliable and predictable service. If one or more pair(s) fail, the system continues to provide service at a lower bandwidth but without a resulting service outage. In an 8-pair bonded Ethernet over copper system, even if 7 pairs fail, service will continue on the single pair until the pairs are restored. Bandwidth restoration allows this to occur automatically. In the case of legacy T1 or E1, if one copper pair fails, the customer will experience a complete service outage.

Reach Further: With Actelis' technology, carriers can provide high-bandwidth services over copper at distances considered unreachable with legacy or other competitive solutions. Actelis' family of EFM repeaters allows carriers to extend the reach of the EFM service to distances exceeding 100,000 feet beyond the CO or fiber-fed remote cabinet. Actelis' XR239SE EFM repeater fits in a standard 239 mechanics housing, simplifying deployment and maintenance of the infrastructure. The repeaters can be deployed for a single DSLAM or remote cabinet, in a linear fashion, or in an add-drop topology to serve multiple remote cabinets leveraging outside plant facilities. Flexibility with rate versus reach allows for flexibility in the designs to meet the growth demands. Repeaters are not limited to strict spacing restrictions; they can be spaced further apart to reach longer distances with lower rates or spaced closer together for higher rates, and can be dual sided power fed to meet both requirements.

When the requirements for data rates are high, the Actelis XR239SE repeaters can be spaced closer together to provide higher rates using fewer pairs. Eight pairs with repeater spacing of 5Kft on 24-gauge copper cable can achieve speeds greater than 50Mbps, depending on spectral mode used. Where the primary concern is reach, repeaters can be spaced further out from one another. As an example, if repeaters are spaced every 10,000 feet, using 24-gauge copper cable (longest segment), 8 pairs (equivalent of 4 T1s) of copper can deliver aggregate bandwidth of 17.6Mbps. In contrast, 4 legacy T1s using 8 copper pairs can deliver only 6Mbps of bandwidth. Distance or reach is defined as the longest segment in a repeated span. Engineers and planners should refer to their Actelis Planning Guide and/or their Actelis Bandwidth Calculator before they finalize their design.

Infrastructure Agnostic Solution: Actelis' products and solutions are agnostic to the make and model of the IP DSLAM. Actelis' equipment treats all of these end points as a termination point for an Ethernet pipe. Actelis product portfolio offers a variety of interfaces to backhaul both legacy T1s and next-generation Ethernet solutions. Actelis' delivery of Ethernet over bonded copper enables carriers to deploy high-bandwidth broadband services over existing copper through their existing DSLAM (IP or legacy), dramatically reducing CapEx and eliminating costly fiber builds.

To make that integration seamless to the end customer, Actelis has spent significant time and effort to work closely and complete interoperability testing with several DSLAM vendors, including Calix, Occam, and Tellabs. Actelis has collaborated with Calix and Occam to design custom cable and hardware brackets for mounting Actelis products in their cabinets, which reduces cost of deployment and accelerates speed to market. These kits can be ordered through Actelis or the DSLAM vendor of choice. Actelis equipment is deployed with several DSLAM vendors including Calix, Occam, Tellabs and Adtran.

Deployment Options and Guidelines

As mentioned above, Actelis EFM solutions are agnostic to the DSLAM vendor and treat the connectivity as a pipe for transport. While most configuration settings in the Actelis products will be the same for all DSLAM backhaul applications and vendors, vendor specific recommendations are listed in the appendices. The specific Engineering and Provisioning configurations required are detailed in this section.

Tools to Help Design the Optimized Solution: Engineering design of the bonded copper backhaul solutions are no different from EFM designs using Actelis' Bandwidth Calculator (available through Actelis Networks or the Planning Guides). This tool allows the user to determine throughput per copper pair based upon the loop makeup. The calculator allows calculations for longer distances (and added bandwidth) using repeaters and works for extended loops up to 100kFT. One of the guidelines for the bandwidth calculator is that the longest segment (between repeaters) will determine the throughput on the entire link. As with all G.SHDSL technology, the available throughput will depend on the number of pairs used and the distance between originating and terminating equipment and the repeater spacing. This flexibility to trade rate for reach (or vice versa) allows for compensating for existing cable gauges, repeater housing(s) or in determining proper repeater housing placement.

Ease of Provisioning: With Actelis' MetaASSIST™ View network management solution, software provisioning is simple and fast. MetaASSIST View is a carrier-class, intuitive, Web-based application that allows management of all Actelis Networks® equipment deployed in the carrier's network. MetaASSIST View, as shown in Figure 3 provides an intuitive Graphical User Interface (GUI) for complete Operation, Administration, Maintenance and Provisioning (OAM&P) of Actelis systems linked to each-other via the HSL bonded copper interface. With complete SNMP support and options for alarming and troubleshooting services, SLAs, like MTTR, can be met and QoS guarantees associated with the service can be monitored and maintained at all times. Advanced troubleshooting tools include tone generation, loopback, TDR, and repeater fault testing tool. Additional features include auto-discovery, graphical bandwidth utilization tool, comprehensive online help, and configuration wizards. For additional information about MetaASSIST View, please refer to the user manual available on the Actelis portal.

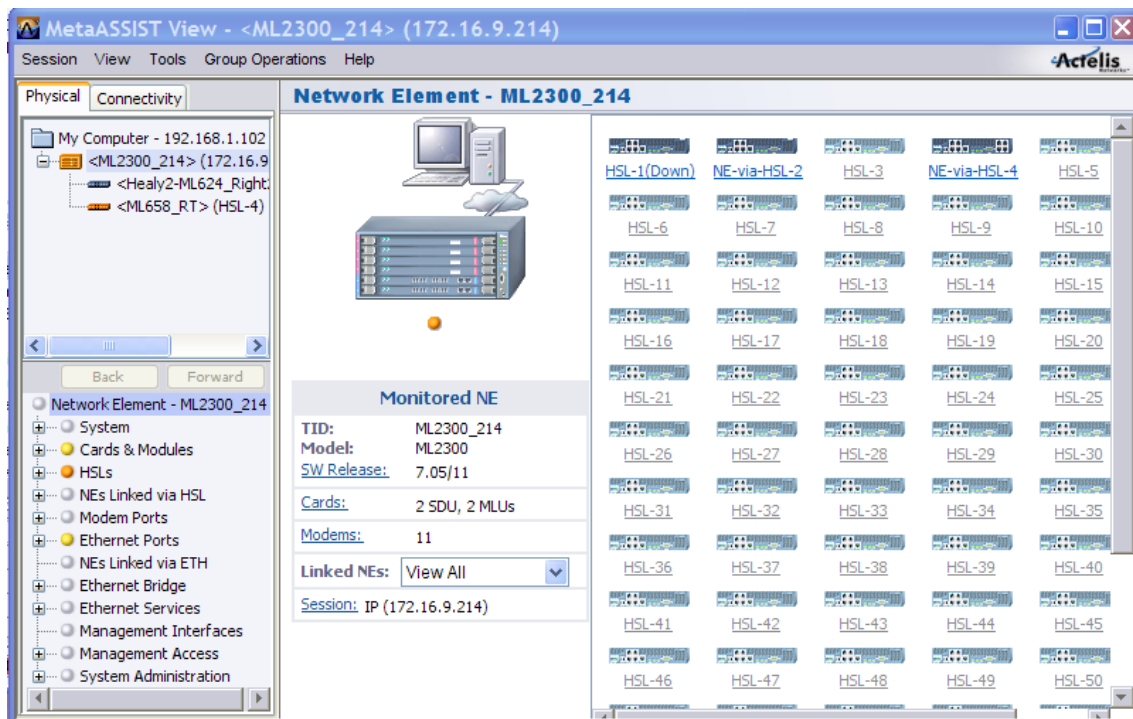


Figure 3: MetaASSIST™ View GUI Provisioning Platform

Provisioning for the EFM circuits for backhaul may be no different than other EFM services. Actelis does recommend matching the VLANs between the DSLAM and the ML devices (Tagged interfaces). Several

detailed provisioning guides have been co-authored by Actelis and the DSLAM vendors and are available upon request.

Design Guidelines

1. Ensure Standards Compliance

While provisioning new services, such as EFM in an existing copper binder, it is critical to take into account and compensate for interference with existing services, like T1 and/or xDSL, in that binder. The ANSI T1.417 specification covers this in detail and all equipment used to provide services over copper must adhere to T1.417 for spectral compatibility. Actelis products have been thoroughly tested and have been proven to be compliant with T1.417 by Telcordia. You can read more about Actelis' ANSI T1.417 compliance online at our Web site under the Tech Forum section.

2. Plan for Growth and Design in Flexibility

When the required bandwidth to any particular T1/HDSL, fed remote cabinet, customer CPE or remote office exceeds what is currently available, Actelis can provide an EFM solution that meets the bandwidth needs and provides a cost-effective option. However, during the design phase it is important to account for capacity growth for DSLAM backhaul. Future bandwidth needs for the particular central offices is driven by the growth in EFM service offerings, such as DIA or TLS services, and can be determined by modeling the growth of such services. Actelis offers several solutions depending on the density of services or backhaul requirements:

- The Actelis ML product portfolio of Ethernet access devices provide the ideal solution for point-to-point configurations, low density, remote cabinet, or small office applications. Specifically, ML638 or ML640 EADs series are best suited for this application. Both devices support up to 8 pairs, have 4 10/100BaseT ports, and 1 100/1000BaseFX SFP port. The ML640 EAD series has a second 100/1000BaseFX SFP port and supports advanced QoS.
- The ML698 is ideally suited for add/drop functionality from the central office to connect multiple DSLAMs on the same copper pairs. This device supports 4 pairs east and 4 pairs west. Figure 4 (Figure 4: ML698 in an Add/Drop Topology) illustrates an application using add/drop design.
- The ML2300 (or 130/698) aggregation platform can be used for both EFM services and DSLAM backhaul. Several customers separate these services between chassis, and dedicate one for end customer EFM services and one for backhaul. Smaller offices or fiber-fed remotes can also be outfitted with a ML130 or ML698 Micro CO device. The Micro CO devices provide the same functionality but support fewer ports than the ML2300.
- Individual segments should not be longer than the equivalent of 10KFT of 26-gauge cable. The calculator identifies this with the Equivalent Working Length (EWL) distance for each segment.
- The longest segment will always be the bottleneck. By evenly spacing the repeaters, based on EWL, the designer can maximize the available throughput.

3. Build in Resiliency

- Design repeatered applications using copper pairs in multiples of 2. This will provide the highest resiliency to longer loops.

Design the circuit for 1 additional pair for cut line protection. Best practice is to overbuild the design; for instance if you need 10 Mbps to a DSLAM on 3 pairs, design the circuit for 4 pairs achieving 12.5 Mbps. If one of the pairs stops functioning as desired, the system will still be

operating at the required full rate. Actelis recommends always using 8 pairs for future planning and ease of growth.

- All pairs are required to be pre qualified using HDSL qualification guidelines. Adding additional attenuation (percentage) on the Actelis calculators allows for copper pairs that may be less than optimal.

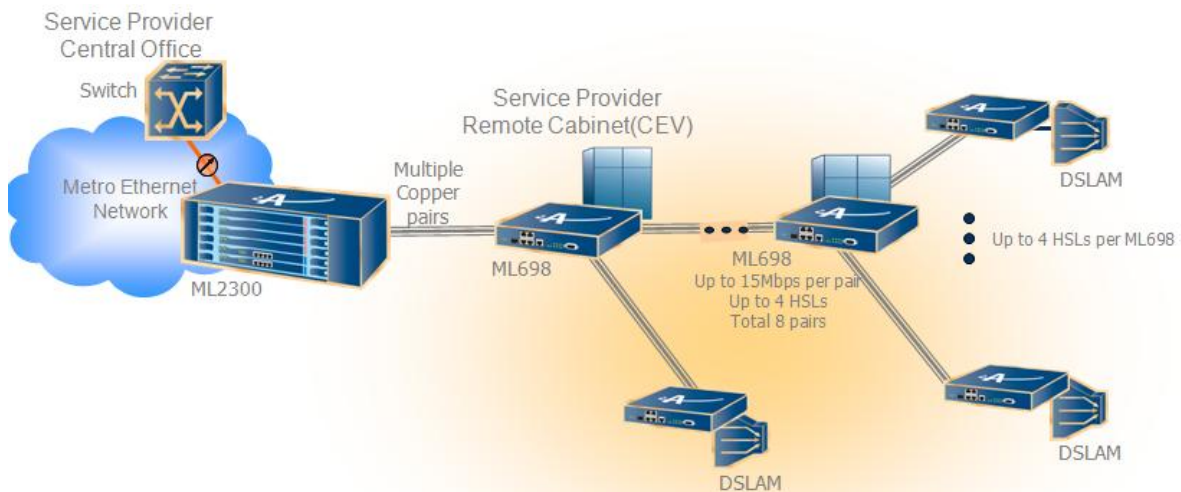


Figure 4: ML698 in an Add/Drop Topology

4. Choosing the Appropriate ML600 EAD

It is important to determine the correct interface between the DSLAM and the Actelis equipment product prior to ordering. In some instances, a SFP port may be required if interfacing with fiber or at Gigabit rates. The rule of thumb is that the ML638/ML640/ML688/ML658s support 100/1000BaseFX SFP transceivers and ML620 series support 100BaseFX transceivers only.

Some equipment in the remote cabinets may require a physical T1 interface(s). The ML654s or ML658s EADs support both Ethernet interfaces and four T1 interfaces transported over a bonded EoC link. A good example is the upgrade of the legacy Tellabs 1000 shelves with GBe222 cards. Using the Actelis backhaul solution enables the GR-303 voice traffic to continue to use the T1s for transport. Broadband services (ADSL), which require the higher bandwidth, will utilize the Ethernet pipe built by the bonded copper (Figure 5).

The Actelis ML65Xs also allows carriers to seamlessly migrate from T1 transport to Ethernet-based connectivity or combine the two. This enables higher bandwidth to the remote immediately and creates a seamless migration path from an IMA or T1-TDM based solution to a hybrid IMA-T1-TDM/Ethernet-IP based solution. This migration path allows carriers to migrate from legacy DSLAMs with POTS T1s at a manageable pace and eliminate the costs of wholesale or forklift upgrades to remotes.

This migration capability is also essential in transforming cellular sites and cellular backhaul to an IP/Ethernet capable platform. With the advent of 3G/4G services and the growing demand for bandwidth intensive mobile applications, most cell sites no longer have the capacity, IP/Package intelligence and network engineering to efficiently deliver these services. This topology and solution is also ideal for low density micro cell applications like pico cells, where the coverage density does not cost justify deploying fiber or microwave-based backhaul solutions.

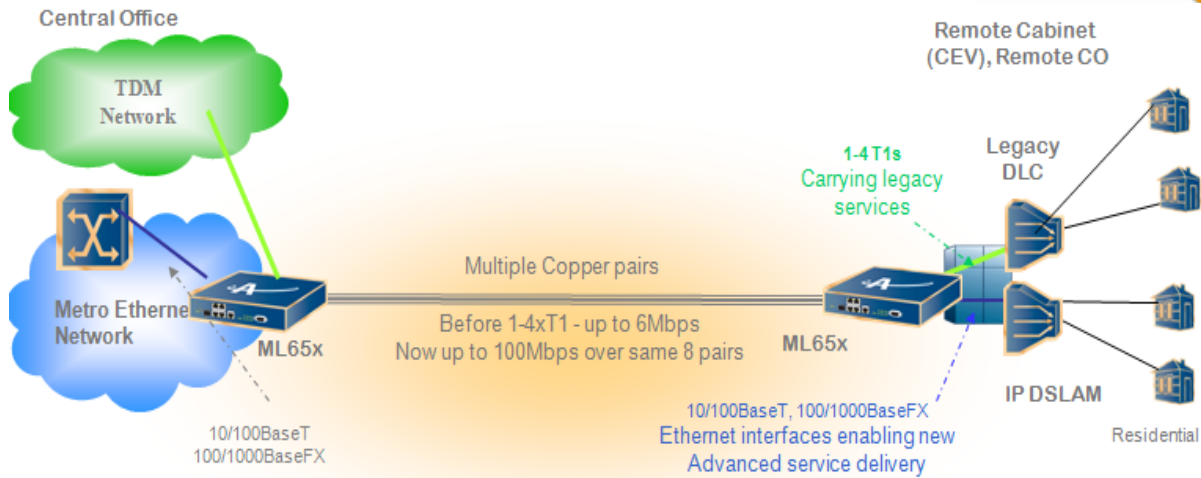


Figure 5: ML650s Transporting GR-303 Voice T1s and Broadband Services

Product Ordering Guidelines

The tables below provide a reference for ordering purposes only. The carrier's network, actual design and implementation may drive slight variations in product types and quantities. Your designated Sales Executive and Sales Engineer can assist with identifying the exact equipment and quantities required.

Central Office	
Equipment	Part Number
ML638 ¹	501RG0067
100' Octal Cable	504R20160
Rackmount Kit	510R21070
PWR & GND Harness	504R20043
Optional equipment	
PFU-8C Kit	501K20098
XR239SE Repeater(s)	501RG20087

Remote Cabinet	
Equipment	Part Number
ML638 ¹	501RG0067
10' Octal Cable ²	504R20120
Rackmount Kit ²	510R21070
PWR & GND Harness ²	504R20043
Optional equipment	
PFU-8C Kit	501K20098
XR239SE Repeater(s)	501RG20087

Table 1: Point-to-Point Applications

Central Office	
Equipment	Part Number
ML2300 Kit	501R00275
100' DSL Cable	504R24008
PWR & GND Harness	504R20047
Optional equipment	
PFU-8C	501R20098
100' PFU-MDF cable	504R24016
100' Octal Cable	504R20160
PFU MGMT cable	504R06055
Rackmount Kit	510R21070
XR239SE Repeater(s)	501RG2087

Remote Cabinet	
Equipment	Part Number
ML638 ¹	501RG0067
10' Octal Cable ²	504R20120
Rackmount Kit [*]	510R21070
PWR & GND Harness [*]	504R20043
Optional equipment	
PFU-8C Kit	501K20098
XR239SE Repeater(s)	501RG2087

Table 2: Point-to-Multipoint Applications

¹ Can be substituted with ML648 (501RG0037) or ML658S (501RG0077)

² Can be substituted with custom cable kits, depending on the DSLAM vendor

Conclusion

Justifying the replacement of existing DSLAM backhauling equipment requires that the new solution be far superior in functionality, be simple to manage, and be cost effective. Actelis can offer such an alternative. Actelis incorporates years of experience in the area of EFM over copper and repeater installations, and this is why Actelis is continually selected by carriers worldwide as the vendor of choice for major IP DSLAM, MSAN, macro and micro cell backhauling projects.

The combination of Actelis' award-winning products, enabling up to 100Mbps of symmetrical bandwidth, extending reach beyond 30km/100Kft, ease of management for multiple repeater hops, complemented by a standards-based approach, makes Actelis' the ideal choice for carriers. Actelis' portfolio of solutions allows carriers to cost effectively meet the growing appetite for bandwidth and support next generation applications over their existing copper infrastructure, delivering the *Rate, Reach and Reliability* critical to every carriers needs. Leveraging the existing copper facilities in lieu of running CapEx intensive fiber will allow carriers to divert their CapEx toward accelerating the ubiquitous delivery of new revenue generating, broadband-rich services and IP-based applications their customers are demanding.

Appendix A

Actelis ML series of products have been rigorously tested for interoperability with the Calix C7 and E5 products at the Calix Interoperability Lab. The following topologies below have been fully tested and deployed in several carrier networks.

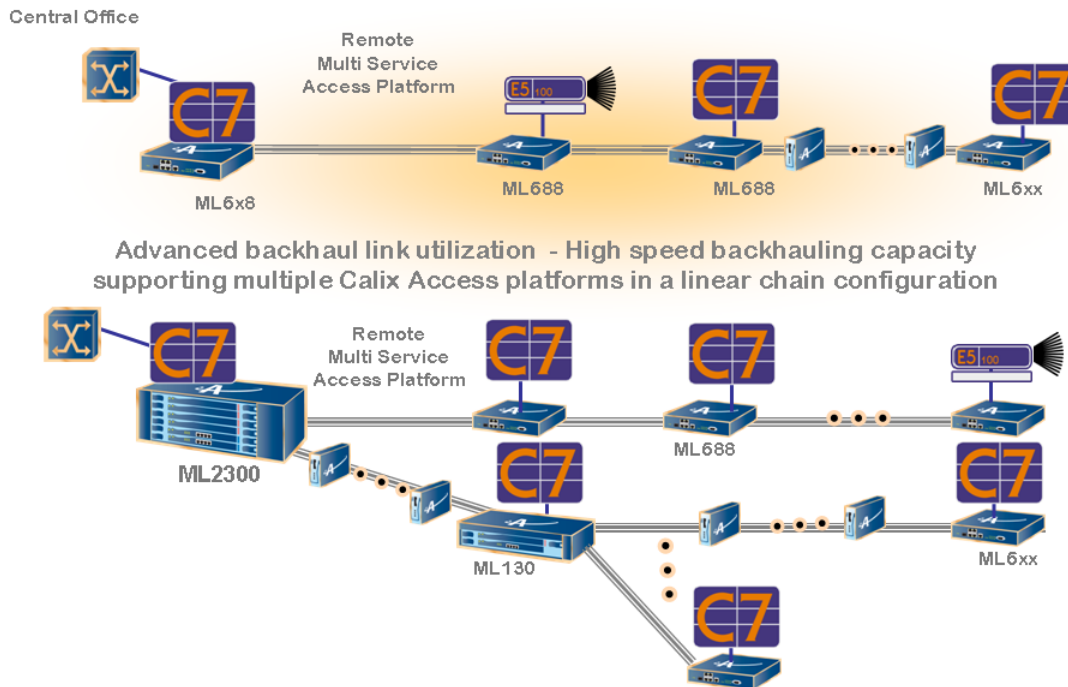


Figure 6: Calix Backhauling

Engineering Considerations:

- Interface to the Calix platform shall be via 10/100 or GigE
- Configure C7 for data uplink
- Configure E-Series product for ADSL2+ data support
- Configure Actelis Ethernet ports as “Tagged”
- Calix E5 performs QoS on their platform and Actelis ETH port honors the L2 COS Bit

The cable and mounting kits that have been developed for Calix and Actelis joint deployment are detailed below.

1. ODC x000E Cabinet

- Actelis P/N: 501S20390: Installation Kit for Single ML600, includes 19" Rack mount sleeve, PWR, GND, Ethernet and DSL cables
- Actelis P/N: 501S20391: Installation Kit for Dual ML600, includes 19" Rack mount sleeve, PWR, GND, Ethernet and DSL cables

2. ODC 100 Cabinet

- Actelis P/N: 501S20392: Includes ML600 Wall Mount Bracket, ODC 100 Mounting Plate, PWR, GND, Ethernet and DSL cables

Appendix B

Actelis ML series of products have been rigorously tested for interoperability with the Occam products at the Occam Lab. Topologies below have been fully tested and deployed in several carrier networks.

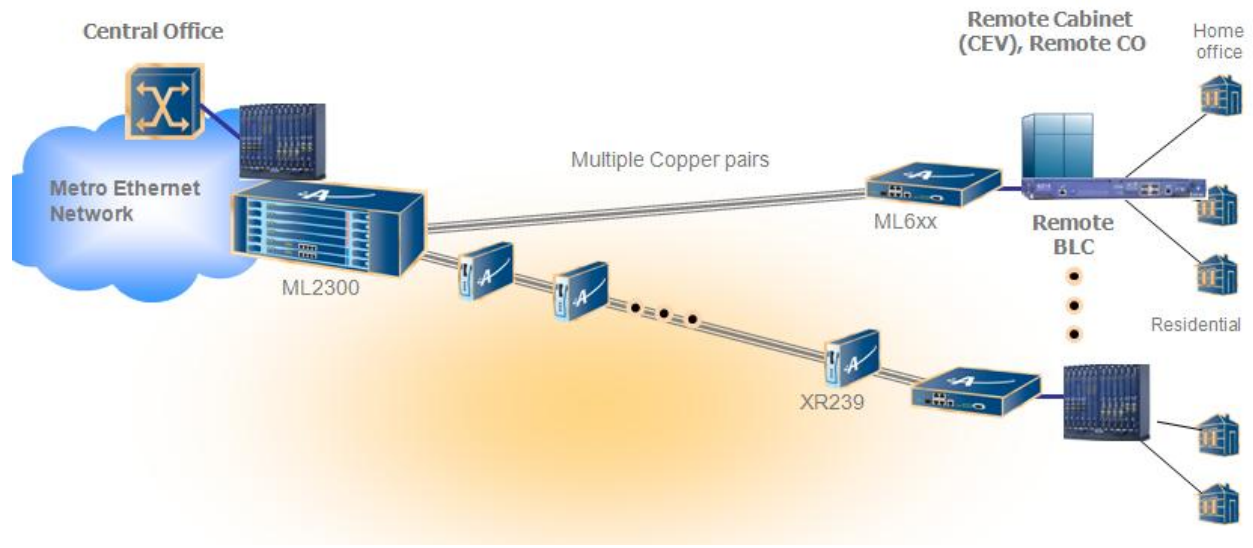


Figure 7: Occam Backhauling

Engineering Considerations:

- Interface to the Occam platform shall be via 10/100 or GigE
- MAC Learning should be OFF on the ML600 remote
- Ring All should be set to OFF and use access VLANS
- Configure Actelis Ethernet ports as "Tagged"
- Occam performs QoS on their platform and Actelis ETH port honors the L2 COS Bit

Specialized cable & mounting kits have been developed by Occam and can be ordered through Occam.

Appendix C

Formal testing of the solution shown below was done by Tellabs and a full report is available. Variations of the below designs have been successfully deployed in several US-based carriers. The drawing below shows a T1000 in the CO. This is not required when doing only HSI.

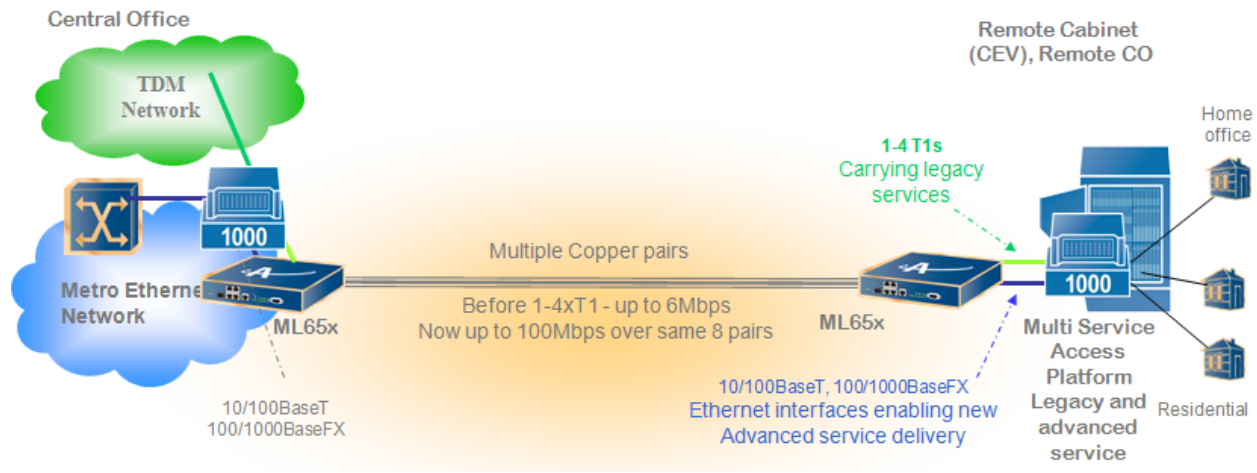


Figure 8: Tellabs Backhauling

Engineering Considerations:

- Interface to the Tellabs 1000 MSAP (GBE222 Card) must be made with a GigE SFP Optical connection – set the Actelis port and the GBE222 port to “auto”
- Actelis CPE that share GigE capabilities are ML638, ML130 and ML648, ML658S
- Configure Actelis Ethernet ports as “stacked” or use the S-VLAN given
- Tellabs requirements - CPU3 Broadband Cards/Broadband Backplane (D-MAX)
- C-VLAN and S-VLAN should be matched to Frontier’s network configuration
- Rate limiting at or below HSL bandwidth is recommended
- GBE222 if used as “transport” from LET to RST dedicates the first 45Mbps to voice. If used as “uplink” the card does not dedicate this bandwidth.

Appendix D

The Adtran 1100F/1124/1148 and 1200F/1224/1248 are predominantly deployed for DSLAM/HSI services. Backhaul the 1148/1248 to the head end and combine with other 1148/1248s.

Engineering Considerations:

- Interface to the Adtran platform shall be GigE SFP
- Actelis CPE that share GigE capabilities are ML638 and ML648 , ML658S
- Configure Actelis Ethernet ports as “Tagged”

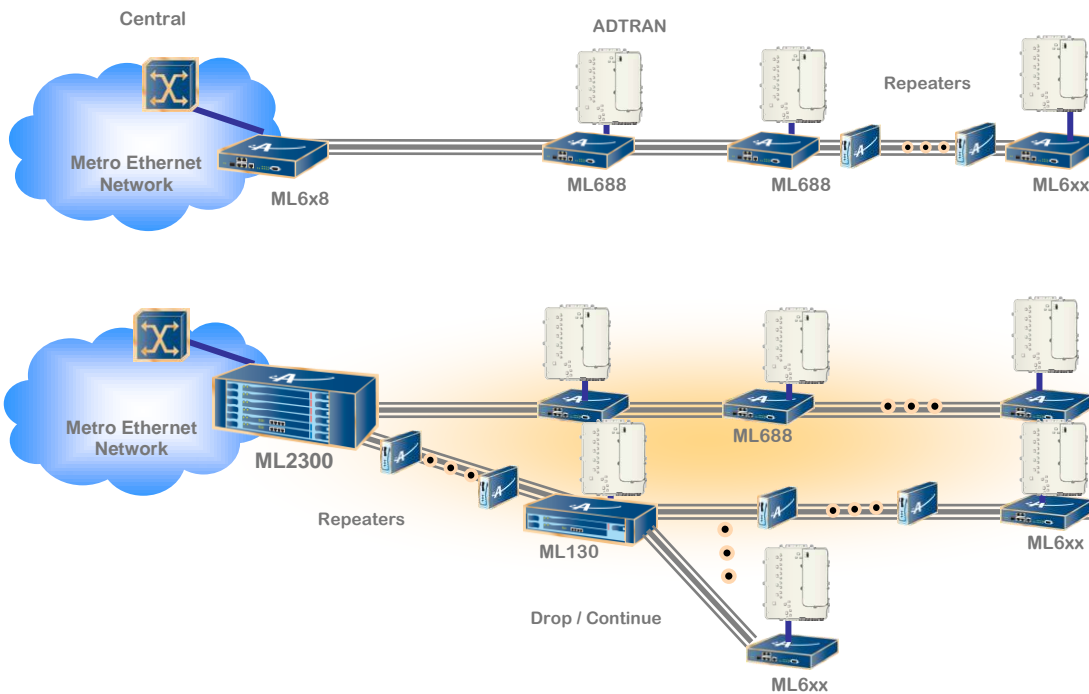


Figure 9: Adtran Backhauling

Appendix E

The figure below shows migration from legacy T1s as transport while maintaining those T1s for POTS or other TDM traffic and enabling a packet (IP/Ethernet) infrastructure. This example shows a Tellabs/Actelis backhaul scenario. The same configuration can be supported for most DSLAM, Remote Cabinet, and MSAP vendors.

This solution is also useful when additional bandwidth is required at macro and micro cell sites.

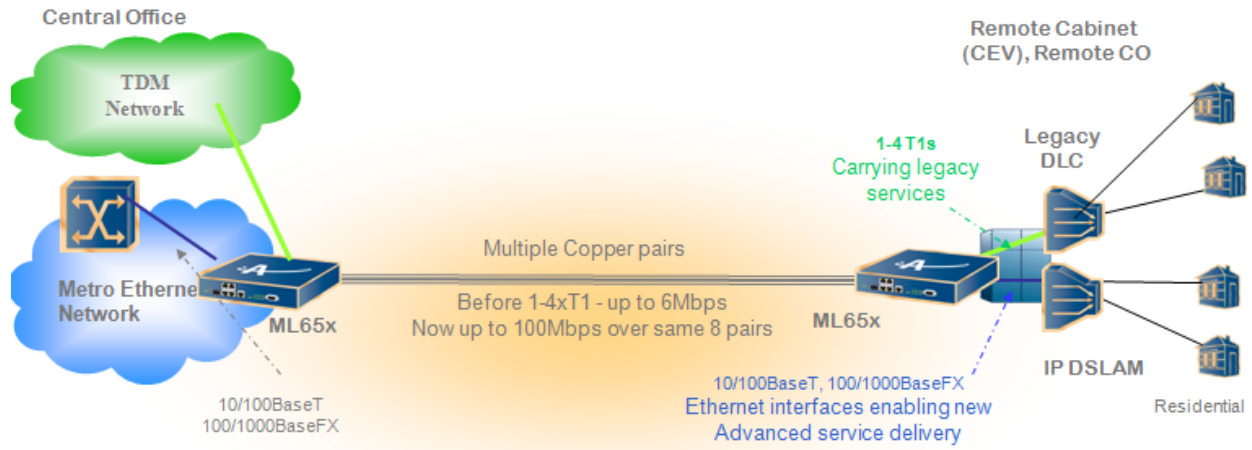


Figure 10: T1 + Ethernet delivery over Bonded Copper

Engineering Considerations:

- Timing for existing T1s can be passed end to end through the adaptive clocking mechanisms in the Actelis ML650
- A maximum of FOUR T1s per ML650. Multiple 650s may be used
- Prioritization of T1 versus Ethernet traffic should be properly engineered and configured in the Actelis EAD.