

Go Native with Native Packet-Optical transport

The key to building efficient Optical Metro Networks for the future

Introduction: Scaling to meet the Ethernet Convergence Wave

Demand for network capacity has ramped up dramatically thanks to the popularity among both fixed and mobile subscribers of video content, music downloads, multimedia-rich web sites, and new applications, as well as thanks to the increasing adoption of Ethernet business services from enterprises. Fixed operators are differentiating themselves with higher speed fixed broadband services, and mobile operators are selling an increasing mix of high speed 3G/3G+ and LTE capable smartphones and mobile broadband services.

But with this ongoing explosion of broadband traffic generating only a small fraction of the revenue per bit that service operators earned from fixed or mobile telephony, VPNs, private lines, or SMS in the past, there is simply no choice but for operators to find a simpler and more cost efficient way to build and scale metro transport networks for the future.

The result of this quest for more cost effective scalability is that service operators have had to evolve their transport networks from the "PDH wave" to the "SDH wave," and now to the "Ethernet Convergence wave." The consensus view in the market is that Ethernet should serve as the unified service protocol, and increasingly that the consolidation of Optical/Ethernet/IP transport infrastructure is important as a means to drive down total cost of network ownership. The support of MPLS-TP is also emerging as a potential tool kit to complement the support of Ethernet and to enhance its transport capabilities in the metro network.

These trends toward convergence on Ethernet and consolidation of multiple transport layers within one network element have resulted in lower CapEx by reducing the need for multiple platforms, and have also resulted in reducing OpEx by simplifying network operations. Those are steps in the right direction. But service operators need to pause now and very carefully assess how they can best further simplify and cost optimize transport within their networks before making such a critical investment. The "tsunami" of the Ethernet services roll out is going to be much too large and far too long to allow the profitable survival of any but the best prepared of service operators.

The need to fully optimize the metro transport network architecture is clear, immediate, and critical. The choice of next-gen architecture for the metro transport network is going to affect its future scalability, flexibility, and cost significantly. As Ethernet is the primary driver of traffic growth in mobile as well as fixed networks, the architecture needs to be optimized with that in mind. By treating the packets "natively", it is possible to inspect and act upon the Ethernet headers so that the combined benefits of Layer-2 intelligence and efficient Layer-1 transport can be realized.

This becomes especially important in the edge of the network where decisions about traffic prioritization are done and where traffic is aggregated to fill the pipes. The best way for a service operator is therefore to optimize that network by employing Native Packet Optical transport supported by MPLS-TP at the edge and metro to provide aggregation, complemented by MPLS-TP and/or potentially OTN in the core. Native Packet Optical transport enables service operators to achieve the most complete simplification of the network, attain the greatest scalability, ensure the highest utilization of bandwidth, reap the benefits of end-to-end OAM, and support various QoS and SLAs while providing differentiated treatment of traffic to ensure QoE over a service aware network.

An alternative proposed by some vendors is to deploy OTN end-to-end throughout the metro core, aggregation, and even to some extent in the access network. But this approach must be carefully weighted on a case-by-case analysis, as it could have some potential disadvantages that service operators need to consider before applying it outside metro core.

This whitepaper explores the relative merits of Native Packet Optical transport approach, and makes it clear why Native Packet Optical transport, supported by MPLS-TP in the metro and aggregation network, and used as a complement to MPLS-TP and OTN in the core, provides the best possible solution to help service providers optimize their transport network for the Ethernet Convergence wave.

This whitepaper was authored by Telecom Strategy Partners on behalf of Transmode.



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Carrier objectives

Carrier objectives for their metro transport networks are clear and straightforward, it is how best to implement the network to attain those objectives that introduces debate and potential confusion. Service operators need to achieve the following objectives:

- The metro network must be simplified to the extent possible, eliminating redundant CapEx costs and streamlining operations.
- This network must also be massively scalable, and must allow that scalability to be achieved with ease.
- That scalability should be optimal for the Ethernet services which are undoubtedly going to be the most important driver of future bandwidth growth.
- The network must support both legacy and next-gen services, and treat them differently.
- Typically the network needs to be able to distinguish between high value IP services and the transport of aggregated pipes.
- The optimal network must be service aware in order to allow differentiated treatment of services, and must cost effectively support the QoS and SLA requirements of each.
- The network must provide OAM on an end-to-end basis.
- The total cost of ownership of the network must be minimized.

All of these criteria can be simplified into one of three categories:

- 1) The need to reduce cost.
- 2) The need to create additional service revenues.
- 3) The need to maximize customer satisfaction and reduce churn.

The Ethernet Convergence Wave and market drivers that caused it

What is behind the unprecedented quest by service operators to increase the efficiency, scalability, flexibility and manageability of the transport network? It is the third wave in transport evolution. The first wave of transport was driven by PDH, followed by services being offered primarily using SDH. Now the third wave is the one consisting of the use of Ethernet as the primary service protocol as part of a cost optimized Optical/Ethernet/IP approach.

The scalability and cost effectiveness of Ethernet have made it the logical choice for service operators besieged with annualized traffic growth ranging from 50% - 200% today, and likely to increase more rapidly in the future.

That massive, unprecedented growth in traffic has been fueled by the explosion of fixed and mobile broadband traffic driven by the utilization of video content from sites like YouTube and TV catch-

up services such as the BBC's iPlayer, downloading music from sites like Napster, and the sharing of personal photos by uploading and downloading imaging files on social media sites like Facebook.



And devices like the iPhone and Android smartphones and netbooks are changing the mobile and portable subscriber experience into one that is increasingly multimedia intensive.

The cost of delivering bandwidth for transport of broadband services is the same as for mobile telephony, yet the service revenue generated by those broadband services is often less than a quarter of the revenue per bit which service operators received in return for their telephony services, and in the case of mobile operators, a much lower fraction than they earned for SMS. And the increasingly varied array of content and applications available to both fixed and mobile subscribers, each of which may have distinct requirements in terms of QoS and network performance, makes delivering all that bandwidth more complex than ever before.

The need for transport network optimization

Service operators all feel the need to radically lower the cost of their transport networks if they are to be profitable in future, and that requires optimizing the cost of metro access, aggregation, and core without compromising on scalability, efficiency, manageability, or the ability to offer differentiated services.

Packet networks have been the industry consensus answer to the resulting transport dilemma, with the convergence of legacy and next-gen services onto Ethernet and the convergence of optical/Ethernet transport layers into a single network element being seen as key to the needed degree of network simplification and optimization.

Although networks are evolving to a simpler Ethernet over optical structure, there are a number of different ways to do this from which to choose, considering that the architecture that service providers choose today will lay the foundation of the network for many years to come.

So how can service operators achieve the objectives needed to optimize their next-gen metro optical transport network?

Network simplification can be addressed through the integration of Layer 1 and Layer 2 transport, which reduces common packaging costs and enables operators to achieve efficient aggregation of Ethernet traffic to maximize bandwidth utilization. The consolidation of optical and Ethernet transport has been the direct response to this requirement. The introduction of L2 switching that can be integrated directly into optical WDM reduces CapEx costs, and provides the means to ensure efficient aggregation.

Massive scalability that can be easily attained can be provided through the WDM functionality in an optical/Ethernet platform, where multiple services can be assigned to the same wavelength or assigned to their own specific wavelength, and new wavelengths can be added on an as-needed basis.

Support for scaling Ethernet services is more important as a solutions criterion than is the ability to scale legacy traffic; doing some of both may be required, but since Ethernet traffic will constitute the great majority of future growth in bandwidth requirements, the network should be optimized with that in mind. If the network can *distinguish between high value IP services and legacy traffic*, that presents the advantage of being able to offload legacy traffic to aggregated pipes to the most cost effective transport at lower layers, avoiding the consumption of ports with higher layer intelligence and also higher cost, except where needed.

Service awareness is critical if the differentiated QoS requirements of all the new multimedia applications and web content are to be met end-to-end throughout the network. And to do that, it is important to retain *service transparency* in the metro until such a point as traffic with like QoS requirements have been fully aggregated to efficiently utilize all the capacity in a big pipe, and to leverage existing investment in VLAN tags and MPLS headers.

End-to-end OAM is important to ensure reliability and resiliency of the transport underlying the services carried over the network,

and is important to ensure both SLAs and service objectives that are internal to the service operator and those that might explicitly be offered to a subscriber.

Efficient aggregation of Ethernet services can solve the problem of underutilized Ethernet trunks at the edge of the network. By “filling the pipes” we increase the utilization of the available bandwidth and ensure an efficient handover to the core network. This approach reduces network complexity and lowers the Opex significantly.

Essentially service operators need scalable, efficient, flexible and manageable transport that can help simplify the network and network operations, and create new revenue opportunities while minimizing total cost of ownership.

As is usually the case, there is more than one way to solve any network challenge from a technical perspective. But there is more to running a profitable network than simply finding a technical solution that works. Service providers in this hyper-competitive market environment need an end-to-end solution that is cost optimized. And that involves selecting the right technology to provide the needed functionality at the lowest cost in every part of the network.

The Native Packet Optical transport approach

Transmode has the solution to optimizing the next-gen metro transport network. The Native Packet Optical network is designed to provide the scalability, efficiency, flexibility and manageability that service providers are looking for, while optimizing costs to enable the profitable roll out of new fixed and mobile broadband services and applications. It does so by integrating key Layer 2 functionality into the optical transport network.

An illustration of the elegant simplicity and straightforward design of the Native Packet Optical transport approach is shown in Figure 1:

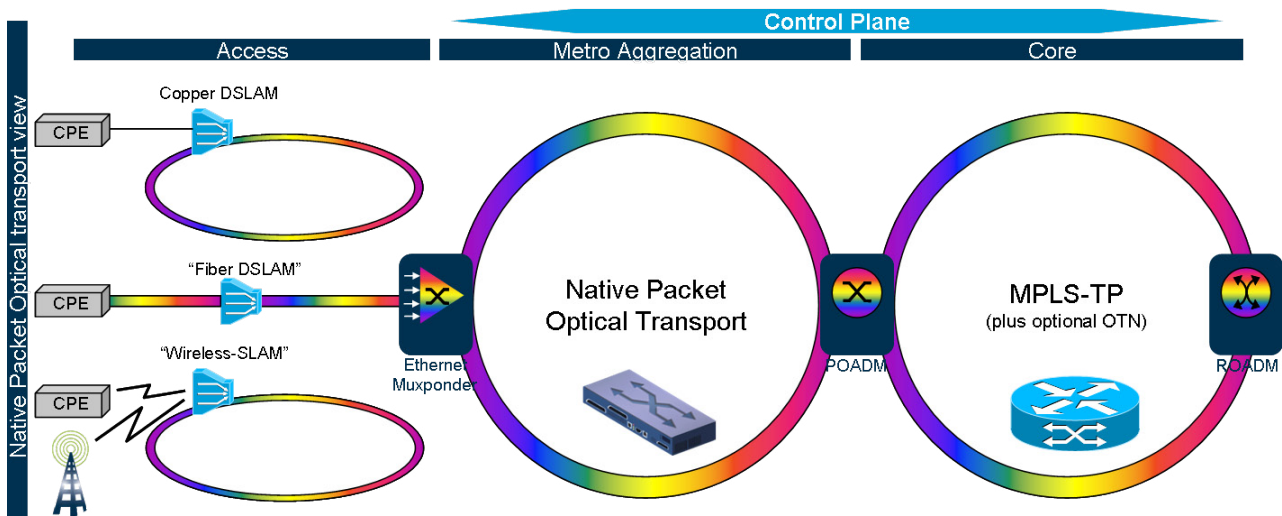


Fig. 1: The Native Packet Optical Network approach

The Native Packet Optical network applies standard Ethernet framing to the main data payload at the edge of the metro network, instead of encapsulating it within an OTN “digital wrapper.” As a result, transport capacity at the edge is utilized much more efficiently because the overhead is relatively low and 100% of the capacity can be used for payload traffic. The wrapping of traffic into OTN is done at the handover to the core, after aggregated “pipes” of traffic are already correctly shaped, avoiding wasting bandwidth.

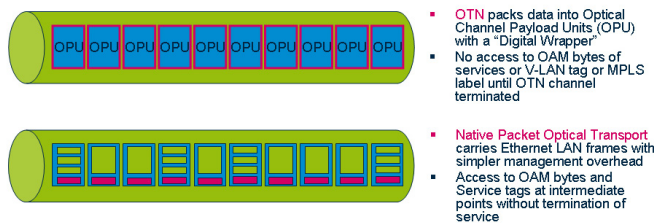


Fig. 2: Comparison of access to OAM bytes in OTN vs. Native Packet Optical transport

The Native Packet Optical transport keeps the main data payload as native Ethernet, specifically 1GbE and 10G LAN PHY. To support the required Layer 1 optical networking functions for optical performance enhancement and in-band management channels to manage intermediate amplifier sites being added, the solution supports overhead for Forward Error Correction (FEC), similar to what is done with OTN except the data payload is a standard Ethernet frame instead of an OTN frame.

This technique has its advantages at the edge of the Layer 2 optical network, since the network traffic is being driven now predominately by Ethernet services with a broad range of QoS requirements, and by keeping the payload as native Ethernet, Layer 2 aware components can be used within the transport network to quickly and simply switch Ethernet frames based on their service type as well as ultimate destination.

Transmode’s Native Packet Optical transport approach uses the VLAN tag and MPLS-TP labels to switch the frames to ports associated with either IP services or with transport services. Each of these service domains is optimized and simplified for the particular service types. For example, frames containing data for high value and high quality IP services (MPLS, IP-VPN or VPLS) can be switched to paths for transport to the necessary IP devices. By contrast, frames that are destined for transport services (Ethernet, MPLS-TP or OTN) can be kept within the transport network, with minimal use of expensive Ethernet switching and IP routing components.

In the Native Packet Optical access network, WDM access is pushed closer to the subscriber. Multi-service WDM Muxponders enable legacy and fast growing Ethernet traffic to be multiplexed onto a single wavelength where required. WDM can accommodate the varying needs of IP services or transport services, providing optimized transport for each - with transport services being kept at lower layers to reduce consumption of more expensive higher layer ports that should be dedicated to the needs of IP services. An Ethernet Demarcation Unit (EDU) ensures manageable, carrier class Ethernet services via a managed demarcation point.

In the Native Packet Optical aggregation network, traffic ingresses to the metro aggregation network via an Ethernet Muxponder (EMXP) card. A packet optimized metro WDM aggregation layer provides transparent transport, which enables simple overhead inspection and OAM access at all intermediate points, and makes better utilization of Ethernet switching technology. Native Ethernet and MPLS-TP are used, providing simplicity and compatibility with an MPLS core.

The metro aggregation and the core networks are connected by the POADM (packet optical add/drop multiplexer) functionality that is integrated into a WDM platform to provide switching at Layers 0, 1, and 2.

In the core, the MPLS-TP enables Layer 2 services and WDM keeps transport services at Layer 1. A flexible ROADM enabled Layer 1 provides wavelength switching capabilities, and a unified control plane extends across the metro aggregation and core networks.

The Native Packet Optical approach entails supporting legacy services using SDH/OTN-based WDM transport services, with Native Packet Optical transport co-existing with SDH/OTN and other transport protocols at the wavelength layer.

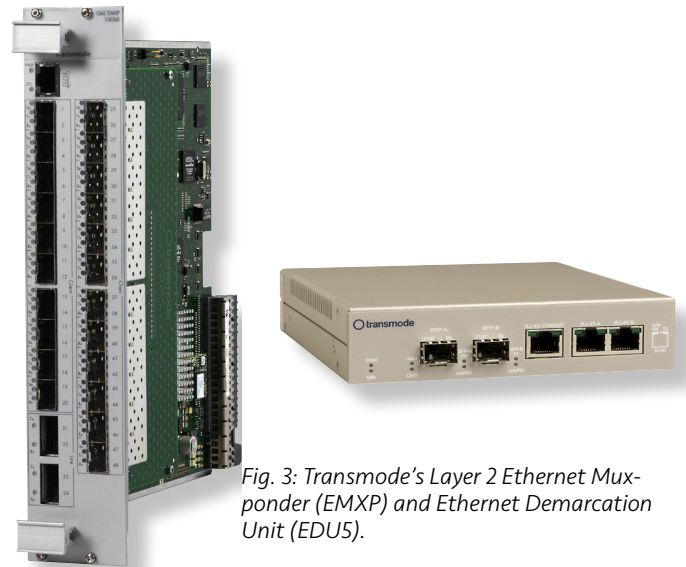


Fig. 3: Transmode’s Layer 2 Ethernet Muxponder (EMXP) and Ethernet Demarcation Unit (EDU5).

Benefits of Native Packet Optical transport

The benefits of the Native Packet Optical approach are many, and provide a stark contrast with the concept of using OTN end-to-end in the network. Consider the following:

- WDM access networks are pushed closer to the edge.
- Native Packet Optical transport carries Ethernet frames with simpler management overhead, and ready access to OAM bytes and service tags is available at intermediate nodes without requiring any termination of the service.
- The availability of OAM bytes and service tags creates an environment in which end-to-end performance management is possible and end-to-end quality of services can be maintained.

- Packet-optimized Native Packet Optical transport allows the selection of network assets to be used to transport next-generation vs. legacy services and big fat pipes to be made at the ingress to the network.
- Aggregation of services onto Native Packet Optical transport enables efficient utilization of transport capacity.
- An integrated Management Control Plane exists between the POADM and ROADM.
- Native Packet Optical transport continues to support SDH/OTN-based WDM transport services, and coexists with these and other transport protocols at the wavelength layer.
- Total flexibility in the growth/legacy traffic mix is attained.
- Migration at such time as legacy services might be phased out is quite simple.

Native Packet Optical transport provides optimized transport that can coexist with MPLS-TP/Ethernet/SDH/SONET and OTN as required. It performs switching functions using established, widely deployed and standardized mechanisms. Furthermore, it provides a GMPLS control plane to manage Native Packet Optical transport Layer 1/Layer 2. In addition, Native Packet Optical transport provides full support for an IP-MPLS core with better network utilization and overall economics, and leverages the existing investments in VLAN tags and MPLS-TP labels.

So how does Native Packet Optical transport compare to OTN, which is sometimes proposed for use in the metro aggregation or even access network? OTN use in the core of the network can be appropriate, but for the metro aggregation part, its use may reveal cost intensive as it may reduce flexibility and increase costs. Consider the following:

- OTN packs data into an Optical Channel Payload Unit using a digital wrapper, and that digital wrapper creates overhead.
- Because OTN uses a digital wrapper, visibility to OAM bytes, V-LAN tags, and MPLS labels are invisible until the point where the OTN channel is terminated - which involves considerable cost if this must be done unnecessarily at intermediate nodes along the data path.

- Without unpacking the digital wrapper, use of OTN in the aggregation network means that providing a service-aware network supportive of differentiated QoS to meet the diverse needs of various services is no more possible.
- Because OTN was developed to add management capabilities for wavelength services, it has the shortcomings of having been designed without a view of Ethernet as the predominant service type in the future, and without recognition for its tags.
- Support for lower speed legacy services riding over SDH/SONET was not in the original design specification for the OTN, which was initially designed with ODU-1 being the lowest speed channel available; vendor proprietary implementations to support low speed services have created challenges in multi-vendor support.
- Since the primary high speed client service of interest is 10G Ethernet LAN PHY, and that is too high for the standard ODU2 OTN frame, creation of another ODU2e standard has been necessary, creating yet more challenges in multi-vendor support so far.
- ODU0 development, an afterthought in the specifications of OTN, must be addressed.

Service providers should put OTN in the best place for it: the core. Once traffic has been sufficiently aggregated, OTN has all the benefits that complement an IP-MPLS core and provide scalable multi-service transport. But in the access and aggregation network where more service granularity is required, a service aware network is required to support QoS, and access to OAM bytes and service tags is required for end-to-end management, Native Packet Optical transport is the better approach because it provides a more efficient, scalable, flexible, and cost effective transport network to help service operators scale to meet the tsunami of Ethernet services that are about to deluge the network.

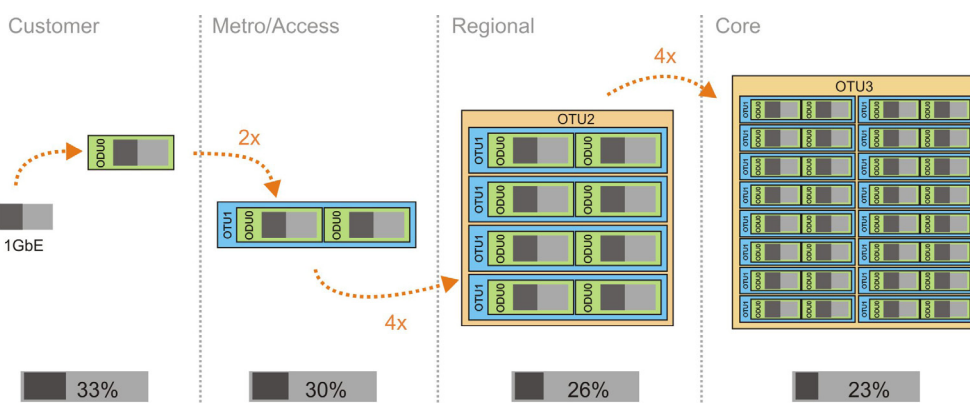


Fig. 4: Example of mapping process of OTN traffic when the average utilization grade of a 1GbE pipe is 33%.

The Native Packet Optical transport roadmap

Transmode's roadmap for the Native Packet Optical transport solution is clear.

- The Ethernet Demarcation Unit and Ethernet Muxponder were early milestones in the Native Packet Optical transport solution.
- The POADM (Packet Optical Add Drop Multiplexer) is a node that provides integrated L0/1/2 switching via ROADM components, using Ethernet Muxponders for Layer 2 Switching and Multi-Service Muxponders to carry various types of legacy traffic at Layer 1.
- The ROADM covers a very important part of the solution as it increases the agility of a network, facilitating the reconfiguration of the optical paths if the traffic requirements change.
- An integrated Management Control Plane is supported between the POADM and ROADM, spanning metro aggregation and core.
- Transmode also sees opportunity to run point-to-point Ethernet services over a WDM ring, using the optical protection and resilience of the ring and enabling upgrades to be done on each node in the ring on a case by case, as needed basis.

The Native Packet Optical transport solution provides maximum investment protection for Transmode's customers, and affords the kind of scalable, flexible, manageable service aware transport network they need to maximize revenues and minimize costs.

Conclusion

Service operators must address the onslaught of scalability, quality of service, and manageability requirements as Ethernet service roll-outs continue to put significant stress on the network and business model, and need the right transport network for the metro as a result. The solution is for them to "Go Native" - using Native Packet Optical transport in the access and aggregation network, potentially complemented by OTN and/or IP-MPLS in the core. This approach makes the most sense for service operators wanting the most scalable and cost effective solution. And by "Going Native," the service provider gains the advantage of using a simple and straightforward approach that provides investment protection.

It is critical that service providers prepare their metro transport network to withstand the full force of the Ethernet Convergence wave, which has only just begun to impact the network with a deluge of scalability and increasingly complex QoS requirements.

The Native Packet Optical network is the logical extension of Transmode's strategy and fully leverages existing platforms and installed base. The roadmap started with development of the Ethernet Demarcation Unit and the Ethernet Muxponder, and that important early development milestone was followed by the introduction of the ROADM. The POADM and ROADM will have integrated signaling management control plane between them.

Transmode's Native Packet Optical network solution is in keeping with the philosophy of providing service providers maximum solutions value by applying the right technology with the necessary functionality at the right point in the network. The result is the lowest total cost of ownership without sacrificing network performance, flexibility, scalability or manageability, and the kind of cost optimized, service aware, carrier class transport that service operators need to maximize revenues and profitability in the future.

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