# Building Next Generation WDM Networks with Multiprotocol/Multirate Muxponders

In order to accommodate increased data, video, storage and TDM/ATM requirements of individuals and enterprises, Carriers, Dark Fiber providers, Utility companies and ISP's are faced with a set of unique challenges: How to cost effectively leverage their existing and new optical networks in order to accommodate current growth and prepare for future expansion in the most effective manner. The considerations that are often taken into account at the planning stage of optical network expansion are as follows:

- Cost effective solution – to stay within budget and get faster ROI
- Compact size – to save rack space and related expenses associated with multiple U's
- Low power consumption to save in OPEX and meet data centers restrictions
- Ease of maintenance and management – to achieve better service and save operational cost
- Supporting variety of service types – meeting current and next generation needs of different user requirements and achieving flexible infrastructure
- Protection of the infrastructure in the event of fiber failure – to increase network reliability
- Low noise and Restriction of Hazardous Substances Directive (RoHS) – to meet green environmental standards

PacketLight Networks WDM product line offers a solution for solving the newly formulated challenges and meets all of the criteria for planning a stable, easily managed and expandable fiber optic network efficiently and at considerably lower costs. PacketLight's muxponder family of products is designed specifically to meet these challenges and provides efficient and flexible aggregation layer of multi-protocol/multirate sub-10G services into common optical transport layer using 10G OTU2 uplink trunks. The multiprotocol/multirate muxponder capability further reduces the number of wavelengths needed for a sub-10G solution by a factor of 8 on average. Increasing fiber utilization and spectral efficiency of data transport further reduces the solution cost and operation complexity.

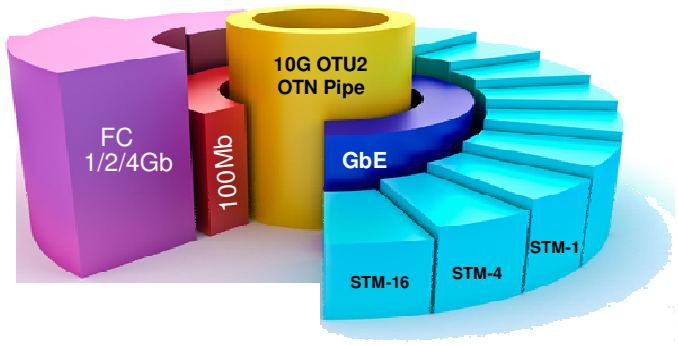
This White Paper further discusses the multiprotocol and multirate muxponder technology and the uses of PacketLight's PL-2000 muxponder product capabilities.

## Muxponder Technology

In today's optical networks, WDM technology (Wavelength Division Multiplexing) is commonly used. With WDM solution, each service whether a GbE, SONET/SDH or Fibre Channel, is assigned an independent dedicated wavelength which then are multiplexed into one single fiber rather then using multiple fibers. WDM technology allows single fiber optic cable to be used for transport of multiple services, thus increasing fiber capacity. However, to even further maximize the fiber capacity, muxponder technology is often preferred.


Muxponder technology, as a part of WDM technology, aggregates multiple services into a single wavelength which are then multiplexed along with other wavelengths into the same fiber. In this model, all sub-10G services are first aggregated into a single 10G uplink and then passing between the sites through 10G wavelength. Therefore, instead of each service having dedicated wavelength, with PacketLight's muxponder, there can be as many as 16 different services that share the same wavelength. With this aggregation method, the muxponder technology maximizes the fiber utilization and presents effective low cost, easy to operate solutions for today's enterprises and carriers.

## Protocol and Rate Agnostic 10G Muxponder




Advanced next generation muxponders provide efficient and flexible aggregation layer of multi-protocol/multirate sub-10G services into single 10G uplink trunk. Using the standard optical transport network OTU2 uplink to aggregate simultaneously SDH/SONET, Ethernet, Fibre channel and Video services, muxponders provide a perfect access platform for multiple clients' needs and allow merger of legacy and new services transparently over the same optical transport layer. The typical rates and protocols supported range from Fast Ethernet to GbE, 1/2/4G FC/FICON, STM-1/OC-3, STM-4/OC-12, STM-16/OC-48 and others. The muxponder solution is often integrated as part of solutions for carriers, dark fiber providers and ISP's due to its carrier grade features such as remote monitoring and management, link diagnostic tools and bi-directional performance monitoring of the client service interfaces and uplink.

Next generation muxponder's main benefits are:

- Significantly reduces the number of wavelengths needed for the optical transport solution
- Simplifies the optical transport network management and maintenance complexity
- Unifies legacy and next generation protocols and services over common optical layer
- Reduces the optical solution cost significantly by:
    - Reducing the number of colored 1/2.5/4G optics by a factor of 8
    - Reducing the number of WDM filters and patch cords/patch panel needed
    - Reducing the optical amplification requirement
- Lowers the power consumption and reduces the rack space needed for the optical solution
- Provides higher spectral efficiency leveraging existing infrastructure for serving additional clients

## Customer Scenario

For explaining the effectiveness of the muxponder capabilities in simplifying the WDM network solutions, we have chosen to explore one scenario for a service provider based on a long distance P2P network. The service provider was requested to provide the multiple client interfaces for several customers over a point-to-point network spanning over 400km. The services transferred between sites are 4xGbE, 1xSTM-16, 2xSTM-4 and 1x1Gb FC interfaces.

In the case of traditional WDM solution (see figure 1.0), in order to transport 8 services in a P2P network, we need to utilize 8 wavelengths inside the fiber. This is achieved by installing 1x8 channel DWDM Mux/Demux at the end sites, Dispersion Compensation Modules, 8xDWDM SFP's and 8xService (Client) SFP's. Due to distance, multiple inline amplifiers must also be installed supporting all 8 channels.

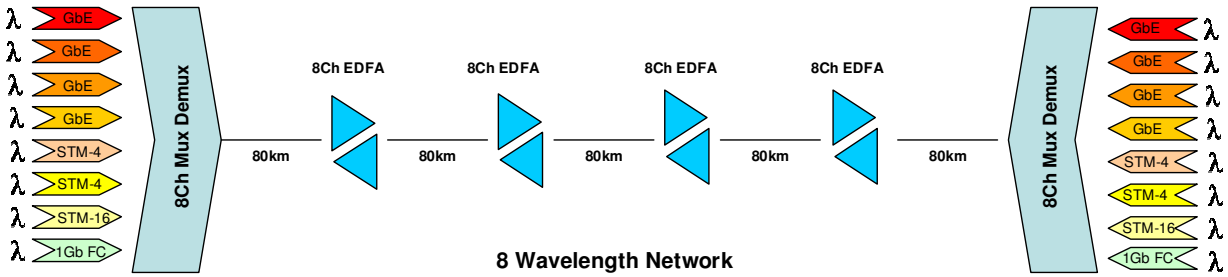



*Figure 1.0*

In comparison, by aggregating all these services over a single wavelength, we can achieve substantial savings in the number of wavelengths needed, as well as in the size of Mux/Demux, number of necessary DWDM optics, and the size of DWDM amplifiers. Using multiprotocol and multirate muxponder, up to 16 services can be mapped into a single 10G OTU2 wavelength at each of the nodes.

In this particular case study, 4xGbE, 1xSTM-16, 2xSTM-4 and 1x1Gb FC client services are used to interface with the client Ethernet, ADM and Fibre channel fabric that are transparently mapped into single OTU2 FEC imbedded uplink port (See Figure 2.0). All client protocols are mapped to a unified optical transport network of OTU2 uplink. The OTU2 standards based uplink port is equipped with single 10G tunable or non-tunable DWDM XFP. The OTU2 port can be protected thus enabling full facility redundancy of the network and fibers. The mapping adds low latency to the end to end solution and maintains transparency to all packet sizes and traffic types. In addition, OTN technology with Forward Error Correction (FEC/EFEC) allows reach to further distances by overcoming the EDFA OSNR (Optical Signal Noise Ratio) in cost effective way rather than using regenerators.

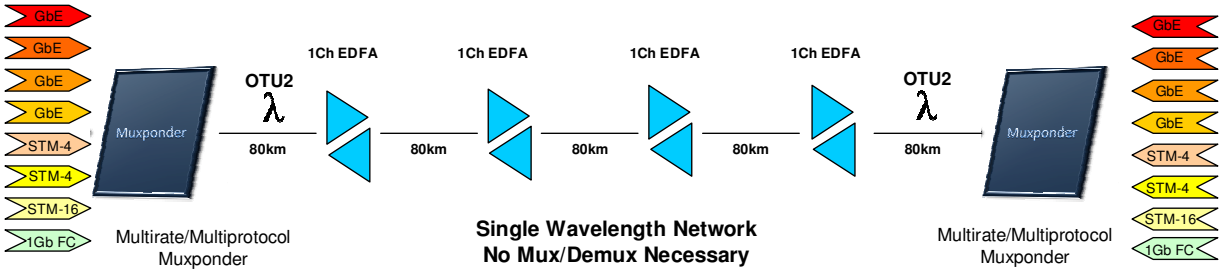



*Figure 2.0*

In this configuration, by using multiprotocol/multirate muxponder at each site, we can transport eight (8) different services on a single wavelength of 10G, as opposed to using 8 wavelengths with the regular WDM solution. Therefore, the total solution in our business case provides the following benefits:

- Maximized dark fiber capacity
- Reduced number and size of Mux/Demux filters and amplifiers
- Significantly reduced number of DWDM SPF's by ratio of 8 to 1
- Significantly simplified the optical transport network management
- Eliminating the need for regenerators
- Reduce the power consumption and solution physical dimensions
- Lower overall solution cost in OPEX and CAPEX
- Enable the service provider to increase the number of clients served over the same infrastructure

## PacketLight's Muxponder Family

PacketLight's family of muxponders prove to be the next generation technology taking wavelength multiplexing to higher levels than ever, in the smallest ever form factor of 1U. They all integrate either on-board or external optical amplifiers (EDFA) and Mux/Demux thus maximizing utilization of any fiber infrastructure to the maximum.

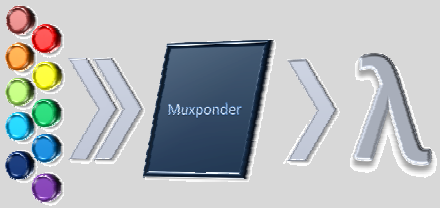
### PL-2000

PL-2000 is the latest addition to the PacketLight's muxponder family and offers the most advanced next generation muxponder capabilities. PL-2000 provides efficient and flexible aggregation layer of multi-protocol/multirate sub-10G services into a single 10G uplink trunk. The 10G OTU2 uplink can aggregate simultaneously SDH/SONET, Ethernet, Fibre channel and Video services, thus providing a perfect access platform for multiple clients' needs and allows merger of legacy and new services transparently. The rates and protocols supported range from Fast Ethernet to GbE, 1/2/4G FC/FICON, STM-1/OC-3, STM-4/OC-12, STM-16/OC-48 and others.

PL-2000 supports two modes of operation. In one mode, it can aggregate up to 16 multirate/multiprotocol services into a single 10G OUT2 uplink pipe with a second 10G OUT2 uplink pipe providing full line protection. In another application, PL-2000 can aggregate 16 multirate/multiprotocol services into a 20G aggregated uplink pipe with OTU2 capability. This application is a perfect fit for ring applications and high bandwidth point to point or ring applications.

Furthermore, PL-2000 boasts carrier feature set which includes remote monitoring and management (Inband or Outband), link diagnostic tools and bi-directional performance monitoring on the client and service interfaces. With the on-board OTN technology and FEC (Forward Error Correction) capability as well as an optional integrated EDFA and an optional integrated Mux/Demux, PL-2000 can be used in long distance backbone applications and is an ideal solution for carriers, alternative providers and ISP's.

### PL-1000EM




PacketLight's PL-1000EM is a fully dedicated low cost 10xGbE to 10G uplink muxponder in 1U small form factor. It transparently aggregates 10 x high density GbE channels with layer-1, ultra low latency mapping into a single protected 10G uplink pipe without any packet loss. PL-1000EM boasts 2x10G uplink transponders which allow the customers to easily create a protected optical network by simply inserting a standards based 10G XFP into the protective transponder. PL-1000EM offers carrier grade feature set such as remote monitoring and management (Inband or Outband management), link diagnostic tools and bi-directional performance monitoring for 10G uplink and GbE client interfaces.

With an optional integrated Mux/Demux, EDFA, and an additional sub-10G multirate transpoder, PL-1000EM provides 10GbE + 1 multirate services and fits perfectly into low latency, high bandwidth, and low cost applications which are suitable for not only ISP's and service providers but also enterprises and financial market.

## PL-400

PacketLight's PL-400 boasts 4 or 8 transponders each supporting up to 4.25Gb multiprotocol services ranging from Fast Ethernet to GbE, 1/2/4Gb Fibre Channel (FC) and STM-1/OC-3, STM-4/OC-12, and STM-16/OC-48. With integrated Mux/Demux and up to two EDFA amplifiers, PL-400 can also integrate up to two muxponders. Each muxponder in PL-400 aggregates 4 services of GbE into a single wavelength with an uplink of 4Gb. Fully populated PL-400 allows transport of 4xGbE+1 or 8GbE+2 services (as demonstrated in figure 3.0) thus increasing the fiber utilization of already existing CWDM or DWDM Network. The PL-400 fits perfectly for data center connectivity or serving high capacity clients. PL-400 architecture is very agile supporting a mix of user configured Multirate transponders and two sets of muxponders.

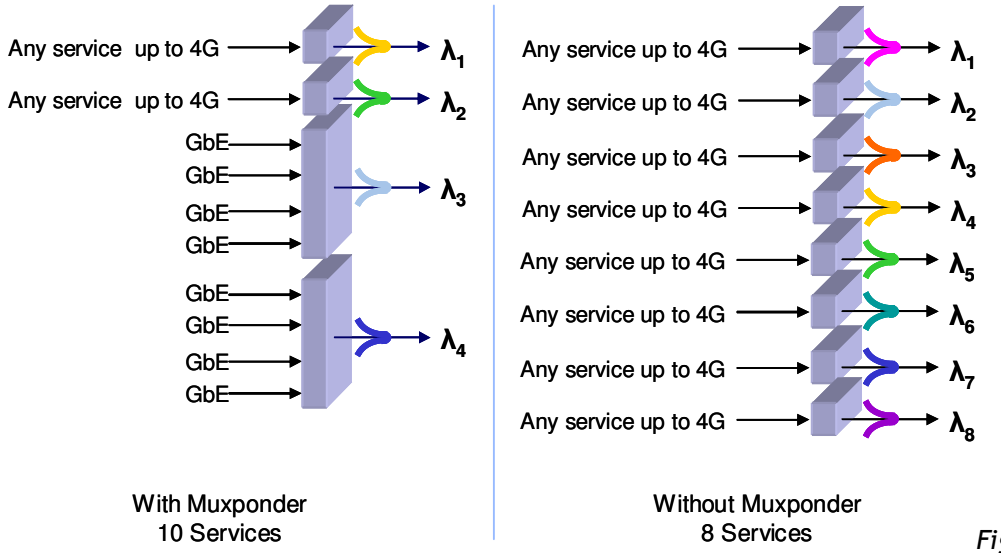



*Figure 3.0*

## Summary

Challenges facing optical network managers are evolving daily. As data capacity needs grow, Carriers, dark fiber providers and ISP's are forced to maximize their optical transport network capacity in a low cost and compact manner.

PacketLight Networks products provide a set of tools and solutions that carriers and enterprises require to design and implement highly flexible and efficient fiber optic WAN networks. PacketLight's DWDM and CWDM product lines and the muxponder capability allow organizations to achieve optimum results with the lowest costs possible thus letting them stay within their budgets.

**About PacketLight Networks, Ltd.**
PacketLight Networks offers a suite of Leading 1U Metro CWDM and DWDM solutions, for transport of data, voice and video applications, over dark fiber and WDM networks, featuring high quality, reliability and performance at affordable prices. Our products are distinguished with low power consumption ideal for CLE (Customer Located Equipment) allowing maximum flexibility as well as ease of maintenance and operation and providing real Pay-as-you-grow architecture. PacketLight customers are carriers, service providers, data centers, IT integrators and enterprises who are active in meeting the demands for metro Ethernet, business continuity, Triple Play solutions and enterprise data sharing applications. For product and reseller information, Please contact: info@packetlight.com