Frequent 10G Adds/Drops in a Long-Haul 100G Network

High-capacity, long-haul 100G DWDM networks can cost effectively support applications where 10G add/drop points are required. This paper highlights the options and describes the pros and cons of each one.

Introduction

Network operators who want to have frequent low bitrate client add/drop points on a long-haul 100G DWDM route have three legitimate options. They can 1) use a second pair of fibers for a parallel 10G DWDM system, 2) share the optical spectrum by adding 10G wavelength in with the 100G wavelengths on the same system, or 3) drop a 100G channel and mux/demux the lower rate clients from it at every add/drop point. Xtera can support all three options.

This white paper includes a high level description of the pros and cons of each alternative, though, due to the unique aspects of each application, it does not provide specific design limits to select an option.

Where there is a requirement for traffic grooming and/or protection at a finer granularity than that supported by the DWDM system without it, an OTN switch may be required. This could be considered a fourth solution for the problem described in this paper. However, given the factors that might justify an OTN switch based solution for this application (such as ODU level grooming or ODU level protection) are not all that common yet and the OTN switch based solution would increase the rack space requirements, power consumption, and potentially cost, it is not considered further in this paper.

One should be aware that, because the digital data is transmitted as analog optical signals in an optical network, the fiber type and attenuation, additional losses, lengths of spans, and number of add/drop points will impact the optical design. In field conditions with standard span lengths, Xtera optical network systems can support distances exceeding 4,500 km for 100G channels between optical-electrical-optical regeneration points. However, long spans (typically exceeding 150 km), fiber with attenuation exceeding 0.25 dB/km, bad connectors or splices can reduce the overall reach, due to the increased optical noise and nonlinearities resulting from the higher optical signal power and amplifier gains required.

This paper does not provide specific claims on the number of add/drop points possible between regeneration points or the distances that may or may not be supported because of the high number of variables involved. Due to the analog nature of optical fiber transmission on long distances, specific applications need to be analyzed individually to determine the capabilities of the optical transmission systems in that application. Reach between regeneration points, amplifier requirements, and the maximum number of channels that may be supported vary from application to application. (In some applications only channels with the best performance can be supported, reducing the overall design capacity.)

Figure 1 depicts the reference 100G network that will be used in this paper to compare the three 10G support options listed above.

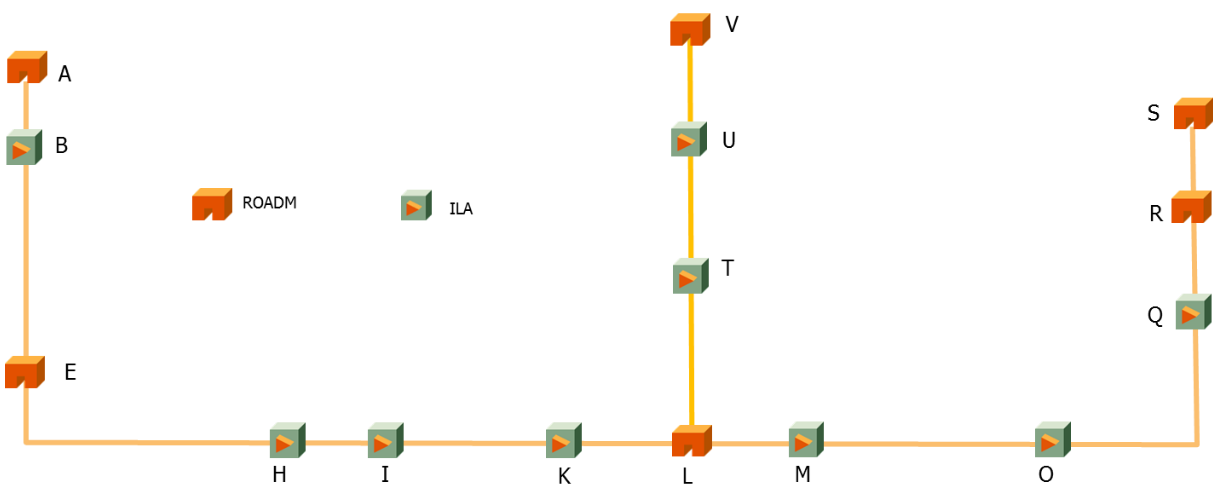

Figure 1: Example of existing 100G network with ROADM and ILA nodes (roughly 2000 km of fiber between node A and node S).

In the reference 100G network shown in Figure 1 are two types of nodes, ROADM and ILA. The Reconfigurable Optical Add Drop Multiplexer (ROADM) includes the following capabilities: optical multiplexing and demultiplexing 100G channels, drop/add of some or all channels to any given port, and power leveling on a per channel basis. Transponders, muxponders, or Optical-Electrical-Optical (OEO) channel regenerators are used to terminate or regenerate channels added and dropped from the ROADMs. The ROADM nodes also include optical amplification, which is the primary function of the In-Line Amplifier (ILA) sites. As needed, gain flattening filters may be employed at ILA sites to extend the reach before a ROADM or OEO regeneration point is needed.

In the options that follow, two other node types are shown, terminals and Fixed Optical Add Drop Multiplexer (FOADM) nodes. Both are less flexible and typically lower-cost options that can be used in place of ROADMs at particular nodes. The terminals are fixed optical multiplexer/demultiplexers with muxponders or transponders to terminate every channel. The FOADM nodes include optical amplification and the ability to add and drop a band of channels that are needed at that node. The channels not dropped/added at a site are passed through with lower loss than those channels might experience going through an ROADM. The power of the band of channels added back onto the fiber by a FOADM can be adjusted by a Variable Optical Attenuator (VOA) in order to level the add channels with the pass-through channels.

Option 1 – Parallel 10G DWDM System

Using a separate pair of fibers for a parallel 10G DWDM system requires a second pair of fiber, which if available and sitting idle may be no problem; but if additional fibers must be acquired, deployed, or leased, the cost for fiber alone may make this an undesirable option. This option inherently requires a second set of systems to rack, power, cool, and manage. That provides a degree of independence between the 100G system and 10G system for operational purposes, which may be a benefit if there is a higher number of changes to the 10G clients which might cause unwanted disruption to the 100G system. However, it requires more space, power, and cooling than the other two alternatives. Having a separate system to manage can also be a troublesome factor, given the need for extra DCN ports and capacity, as well as many more elements to monitor and maintain. This option is illustrated by Figure 2.

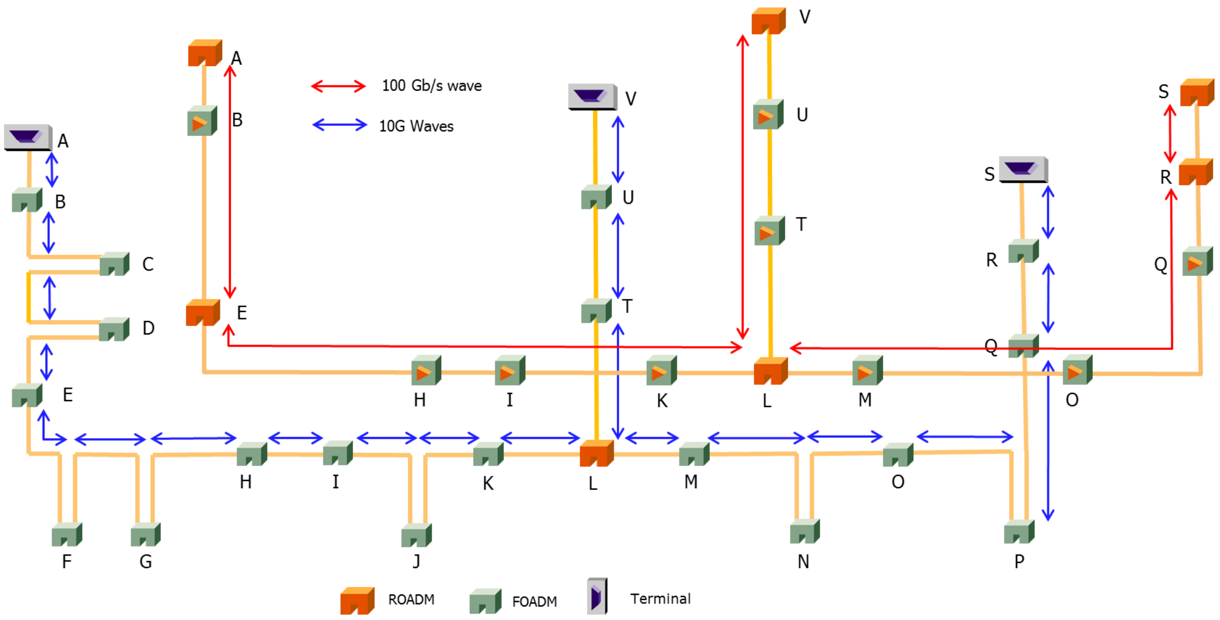

Figure 2: Example Option 1 – Parallel 10G and 100G systems on separate pairs of fibers.

Option 2 – Combined 10G & 100G DWDM System

Option 2 allocates a portion of the optical spectrum for 10G wavelength and a portion of the spectrum for 100G wavelengths on the same DWDM system. This reduces the overall system capacity by only assigning 10G signals to wavelengths that could be used to carry 100G. Depending on the service flexibility that is needed, FOADM modules may be used to reduce costs in place of more flexible but more complex ROADMs where new 10G add/drop points are required. The additional benefit of FOADMs in this application is that they do not degrade the transmission of pass-through 100G wavelengths. Figure 3 represents this option.

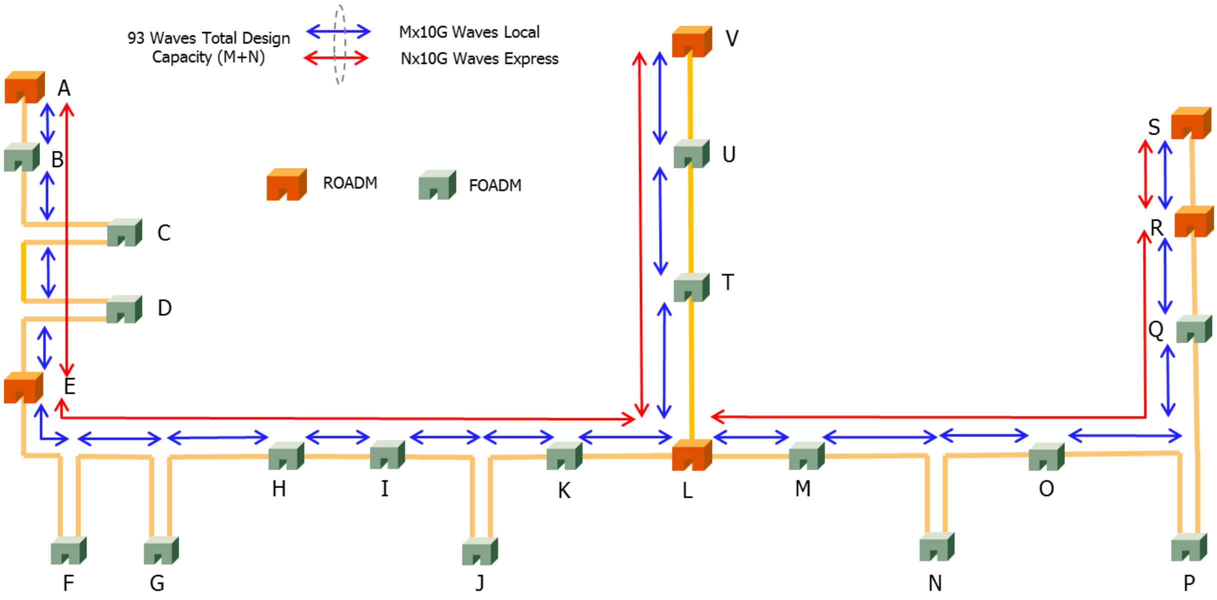

Figure 3: Example Option 2 – 10G and 100G wavelengths sharing the same fiber pair and transmission system.

This option has the same advantage as Option 3 with respect to utilizing a single system for the 100G and 10G wavelengths with the added advantage of lower power requirements and cost due to the fact that 10G transponders/muxponders are lower in both respects than 100G versions. Using 10G waves, particularly where only a small number of 10G clients are needed, also has the advantage of not requiring the mux/demux to and from a 100G signal. Another advantage is that a 10G muxponder may be used to terminate the 10G wavelengths, capable of many lower rate client ports without an additional module for mux/demux. (Note that most 100G muxponders support fixed 10x10G client ports because supporting lower rate clients would either require a very large number of client ports on the module or strand bandwidth.)

One disadvantage of this option is that one must separate out the 10G channels to run them through dispersion compensation modules (using FOADM or ROADM modules) at each site where the spacing of 10G drop points are beyond the reach limit to go without them. (Chromatic dispersion is an inherent characteristic of optical fiber that varies with wavelength. The chromatic dispersion limit for 10G optical transmission in the 1.5µm window without compensation or regeneration is typically in the 80km range for standard single mode fiber.)

Option 3 – 100G DWDM System

Option 3 is to simply enhance the 100G system to enable 100G add/drop at every site where the low bit rate client drops are needed. A muxponder can drop 10G out of the 100G wavelength to whatever client edge device is used. This option is illustrated by Figure 4.

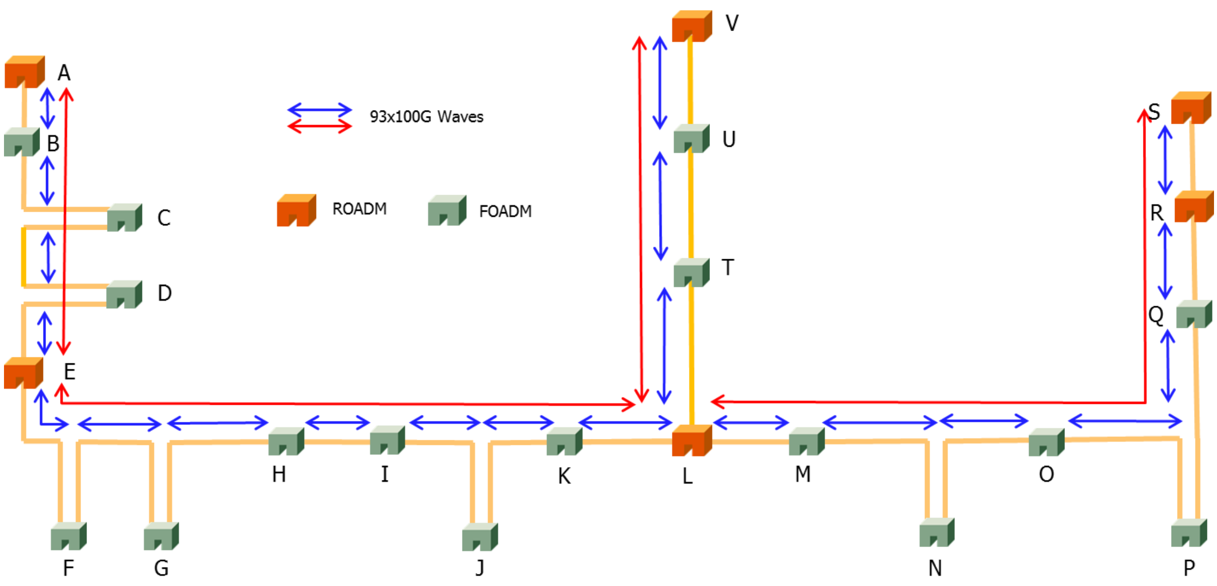

Figure 4: Example Option 3 – Enabling frequent 10G drops via 100G Muxponder (10 x 10G) at 10G sites.

This option is the most elegant and simplest of the three options, in that it utilized a single pair of fibers, a single set of elements, and all 100G wavelengths. However, depending on the number of 10G add/drop points and where they are in relation to the needed 100G add/drop points for other clients, it may be more expensive than the other two options due to the need for many more 100G transponders. In the specific case of the example used for figures in this paper, the cost of upgrading the 100G network shown in Figure 1 with Option 3 was only 5% higher than Option 2. It requires the same number of ROADM points on the 100G system, which may utilize lower cost FOADM modules as in Option 2, if remote reconfigurability is not essential. Another advantage of this option, depending on the spacing of add/drop points, is the fact that this option relies completely on 100G coherent receivers, making is far more tolerant of chromatic dispersion than the 10G wavelengths used in Option 2 and minimizing latency for 10G services.

Conclusion

All three of these options have their advantages and disadvantages. As a result, the operator requirements and the unique characteristics of a network with the need for frequent and/or flexible low bit rate client add/drop points along a long haul 100G DWDM route need to be analyzed to determine the option that best fits that specific application. As already done for existing customers, Xtera is interested in modeling potential customer networks to propose the best fit solution for a given application.

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