FLEXIBLE REGIONAL NETWORKS USING BROADBAND OPTICAL ADD/DROP BRANCHING UNITS

Mark Enright

menright@tycotelecom.com

Tyco Telecommunications, 250 Industrial Way West, Eatontown, NJ 07724, USA

Abstract: The broadband Optical Add/Drop Multiplexing Power Switched Branching Unit supports effective solutions for regional and offshore petroleum networks with complex connectivity requirements. Some key equipment features for the broadband OADM network are passive optics in the undersea plant and optical control of the powering configuration of the Branching Unit. The broadband feature of the optical couplers in the Branching Units enables high reliability and a very high degree of network flexibility. This paper reviews the equipment developed to implement such a system as well as enhancements for the future.

1 INTRODUCTION

Optical Add/Drop Multiplexers (OADM) have been part of the network designer's toolkit for over 15 years. They have been widely deployed in terrestrial networks and have also been installed in a few undersea networks. With the exception of the latest generation of terrestrial ROADM (reconfigurable OADM), OADM implementation typically had a fixed portion of the optical band dedicated to the add drop channels. As a result, the add/drop bandwidth was limited and fixed at the time of network installation. While this may be a manageable constraint for terrestrial networks which allow easy access for modification of the OADM optics to increase the Add/Drop band as traffic demand grows, in undersea networks the installation of an OADM BU creates a potential choke-point in the network. Fortunately, a simple architecture using readily available couplers/splitters can be employed which greatly increases the flexibility of undersea OADMs.

2 OADM APPROACHES AND APPLICATION

The following discussion will present the various different types of OADM and discuss the benefits and considerations for use in a network.

2.1 Traditional OADM

An OADM consists of three stages: (i) the optical demultiplexer, (ii) optical switch or add/drop stage, and (iii) the optical multiplexer. The optical demultiplexer functions to separate wavelengths on an incoming fiber pair onto the desired output fiber pairs. These fiber pairs are then either dropped or directly connected to optical multiplexer. The last stage is optical multiplexer which functions to multiplex all those wavelengths either added, directly from optical demultiplexer, or from the incoming fiber pair, to the outlet fiber pair [1,2]. Figure 1 shows a diagram of a typical OADM.

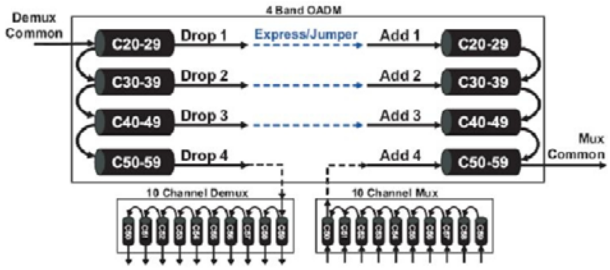

Figure 1: Example of a Fixed OADM (Courtesy of Bookham)

The Add/Drop band is implemented via optical filtering, which will select a portion of the transmission band to be dropped at the branching unit as well as passed directly through. By selecting the pass-band of the filter, the amount of capacity dropped and by-passed can be adjusted. Since filters have some roll-off (i.e. the transmissivity of the filter is non-ideal) a portion of the transmission band must be allocated for this roll-off . This portion is known as the dead-band and can be several hundred GHz and reduced the total number of channels that the network can support.

Historically, undersea network applications of OADM branching units have used fixed optical filters to implement the Add/Drop capability. Fixed filters are used to meet the high-reliability requirements of undersea networks and are typically an incremental change to filters already qualified for undersea use (e.g. gain equalization filters). Using a fixed filter pre-determines the allocation of capacity to the through path, the add/drop path and the size of the dead-band at the time of network construction. Therefore, network designers must be certain that the subset of total capacity dedicated to an add/drop branch will be sufficient for the life of the system.

2.2 Dry OADM

One approach to overcome the "bottle-neck" associated with fixed undersea OADM branching units is to install an OADM function in the Submarine Line Terminating Equipment (SLTE) at a branch station. As can be seen in Figure 2, the optical multiplex/demultiplex portion of the SLTE can be configured to by-pass express wavelengths and terminate only those wavelengths required at the branch station. As with the undersea OADM, fixed filters are used to partition the transmission band. However, the OADM implementation in the SLTE has the advantage that the partitioning can be adjusted by changing the filters.

While the Dry OADM is more flexible, special consideration must be given to the express channels. With a dry OADM the express channels will have a double transit through the branch adding 2x the branch lengths to the Digital Line Section (DLS) of the express traffic. This can be treated either by shortening the repeater spacing or reducing the total number of express channels. While neither of these options is particularly desirable, it is often possible to reduce the initial cost of a lightly loaded system by implementing dry OADM since the reduction in express capacity does not restrict the initial topology. As the capacity demands increase for the network, the Dry OADM can be converted to conventional back-to-back SLTE terminations.

Another consideration of the Dry-OADM is the vulnerability of the express traffic to a break in a branch segment. Since the express traffic passes through a branch location, should that branch segment encounter an outage, the express traffic will be affected. Depending on the likelihood of disruption and the availability of network protection paths, such as via an express fiber, the network may still provide sufficient performance. If not, this approach may not be viable.

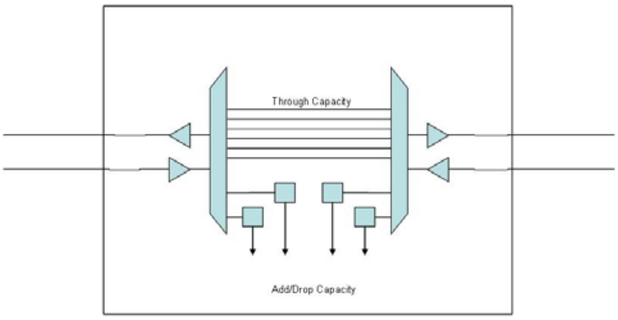

Figure 2: Dry OADM

2.3 Broadband OADM

Another approach to OADM is to eliminate optical filters completely and use couplers and splitters to allow access to the entire optical spectrum at an add/drop location. Figure 3 shows an optical schematic for such a device. At the input of the Broadband OADM, the spectrum is split and passed both to the drop leg and the express path. A second combiner in the path adds the spectrum from the branch leg to the spectrum passed in the express path of the preceding coupler. Through the use of wavelength assignment, a flexible and adjustable OADM architecture can be implemented. Proper wavelength assignment is critical as the entire spectrum is both passed and dropped. Therefore a separate assignment for the add and drop wavelengths must be maintained. The benefit of this approach is that the entire spectrum is broadcast to all nodes and add/drop capacity can be adjusted simply by installing un-assigned wavelengths at the node(s) of interest. Since the architecture is implemented using broadband couplers and splitters dead-bands are avoided.

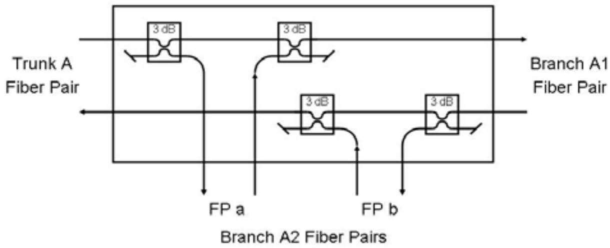

Fig. 3. Broadband OADM

3 SYSTEM APPLICATIONS OF THE BROADBAND OADM

One network application that lends itself particularly well to Broadband OADMs is in linking Offshore Platforms. In this application a variation of the classic repeatered trunk and branch topology is applied which uses broadband OADM to provide a robust network configuration. Many Offshore Petroleum regions contain platforms which can range in distance from one another and the shore of a few tens of kilometers to a few hundred kilometers [3-5]. Since these distances are well within the range of repeaterless links, it is often possible to connect the platforms in a "daisy-chain" manner as shown in Figure 4. The disadvantage to this approach is the dependence of platforms more than one node from the shore on the operation of subsequent platforms to maintain the link. Thus, should some platforms become disabled, those platforms beyond the disable platforms can become isolated.

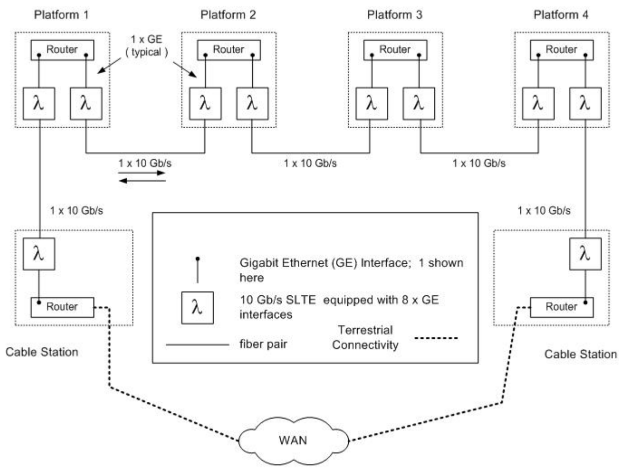

Fig. 4. Daisy-Chained Repeaterless Network

This deficiency can be overcome by implementing a repeatered trunk and branch configuration with each platform having a dedicated link to the shore terminals without passing through any other platform. In its most basic form, this approach would have an east and west bound fiber-pair for each platform. Since typically it is desired to connect many platforms, this dedicated fiber approach becomes impractical. Through the use of OADM branching units as seen in Figure 5, each platform can be assigned dedicated wavelengths instead resulting in a robust and efficient network. As discussed previously, by using a broadband OADM, each platform has access to the entire transmission spectrum and each platform is now communicating directly to the shore terminals with no intermediate terminations. Through the proper assignment of channels, tens of platforms can be connected to a fiber pair with capacity available for upgrades. The repeatered trunk and branch aspect of the network make each platform completely autonomous from any other platform and in the extreme should all but one platform be disabled, the remaining platform can still communicate to the shore terminals. Of course, transmission can be affected by interruptions to the trunk cable, but through the use of a ring topology by terrestrially linking redundant shore stations, the network can tolerate a trunk fault.

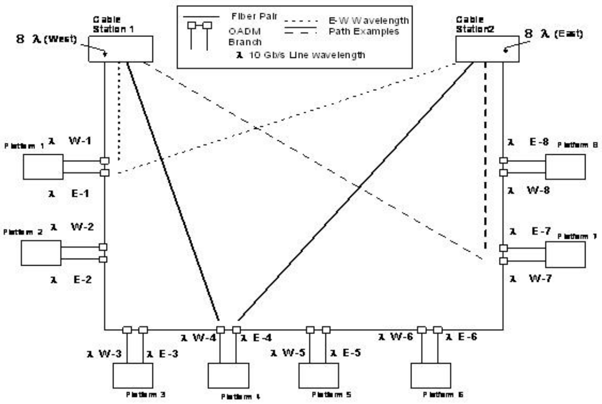

Fig. 5. Offshore network using Broadband OADM

4 CONCLUSION

OADMs provide a potentially useful tool to network designers. While each implementation has some limitations, these limitations may be acceptable for certain applications. The Broadband OADM is a novel approach that can provide a reliable and cost-effective solution for undersea networks . In the long term, Recofigurable OADMs (ROADM) may provide even greater flexibility to network designers. These devices have adjustable Add/Drop bands which can be varied during the life of the system. Thus the limitation of fixed filter drop-band and the inherent choke point that results can be overcome. As with the previous generations of OADM, limitations and trade-offs need to be considered when applying an ROADM to an undersea network. However, these tradeoffs are much less constricting and suggest that ROADM will become a very useful tool in the future design of undersea networks.

5 REFERENCES

[1] “Four Band OADM”, www.bookham.com/datasheets/thinfilters/ttff_4band_oadm.cfm, Bookham Inc., Retrieved on February 2007.

[2] “OADM,” http://www.optical-network.com/terminology.php?letter=all&id=8, Retrieved on February 2007.

[3] J. Byous “Sea Change – The Coming Sea Change in the Gulf of Mexico Communications” Subtel Forum Issue 10 November 2003.

[4] G. Arnos “Bandwidth in the Oil Patch” Subtel Forum Issue 22 September 2005.

[5] O.H. Nordgard “Executive Forum” Subtel Forum Issue 16 September 2004.