Scaling High Capacity Optical Networks

Advanced Alien Wavelength Solutions

The advent of high-bandwidth over-the-top (OTT) services, the explosion of broadband and mobile data in emerging markets and the growth of large web-based internet companies such as Google, Amazon and Facebook is creating a disruptive impact on the wholesale bandwidth industry. Over the last few years, Alien Wave technology has emerged as a popular, technologically mature and cost-effective method to rapidly upgrade capacities on "brownfield" DWDM networks without having to invest in a new capital-intensive network. In this paper, we provide an overview of Alien Wave technology, benefits over conventional solutions, common implementation challenges and mitigation techniques to ensure a resilient and high performance deployment.

White Paper

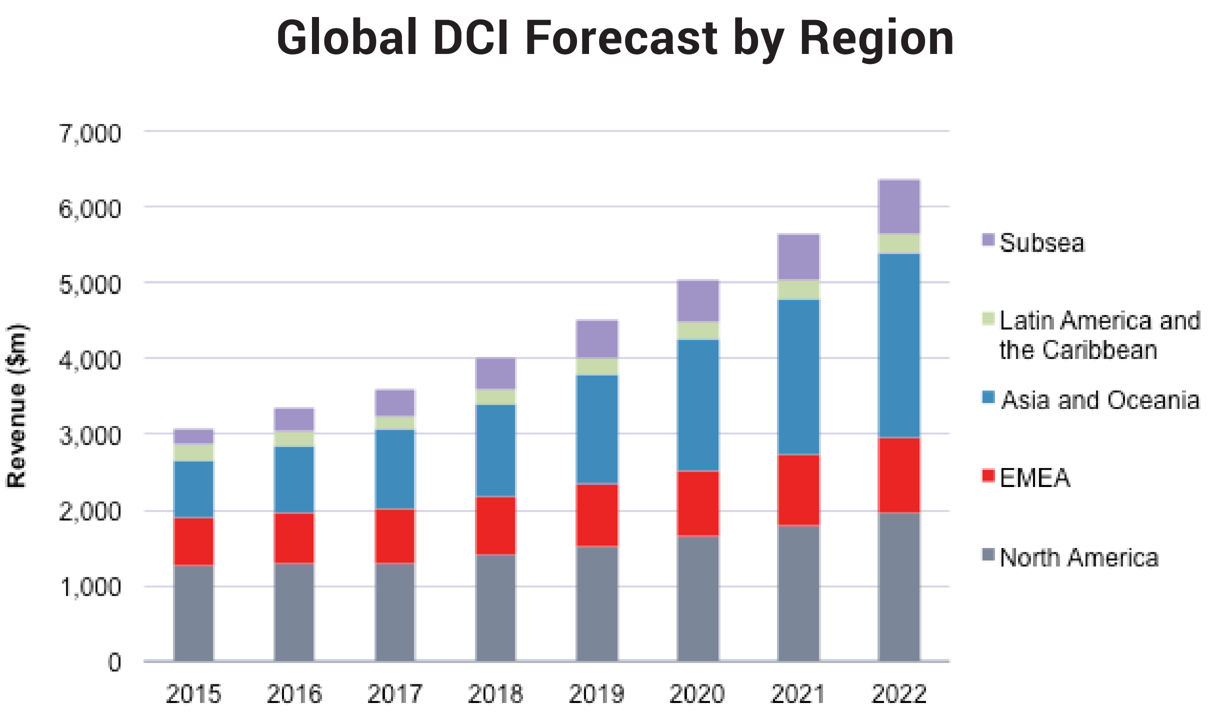
Introduction

The ever growing demand for bandwidth is pushing telecom service providers to explore and adopt new approaches to stay competitive by coming up with advanced technology solutions that are economically viable and achieves lower cost-per-bit. One recent development in the DWDM space which has captured global market attention is Alien Wavelength (AW) transport.

AW transport involves transparent transmission of coloured optical channels over pre-existing third-party physical infrastructure. In other words, AW transport implies an innovative spectrum utilisation arrangement between an optical infrastructure owner and a bandwidth crippled customer. The fact that multiple providers co-exist and utilize the common fiber and optical layer infrastructure turns out to be a viable and cost-effective way to scale-up network capacity through minimal capital and operational investments. A practical example of an AW implementation is one where network resources owned by one carrier are being utilised to transport optical channels that are in the control of a secondary carrier. The possibility of AW insertion without any impact to existing services has resulted in a rapid acceptance of this technology by the telecom service provider community.

Market Drivers

Globally there is a large and growing market for wholesale bandwidth services ranging from hundreds of megabits to hundreds of gigabits. Wholesale bandwidth providers typically build and maintain a high-capacity DWDM network and sell bandwidth to other service providers in the form of optical wavelengths who in turn resell lower-granularity connectivity services to multiple enterprises or retail customers. Wholesale bandwidth providers include large integrated telecom operators having surplus capacity in their networks or large utilities that have significant fiber assets which can be leveraged to realize a profitable bandwidth business.



Source: Ovum Report - Global Data Center Interconnect & Purpose-Built DCI Forecast Report: 2017–22

In recent times, growth in the wholesale market has been accelerating on account of emergence of large web-scale companies, high-bandwidth video applications and rapid expansion of cloud-based services which is resulting in greater investments in new data center build-outs and expansion of intra-data center infrastructure. As a result, there is a greater need to build large bandwidth pipes to inter-connect these data centers (DCI) which is driving demand in the wholesale market. As per Ovum, the wholesale market will be worth $213bn in 2021, accounting for 10.8% of total telecoms service provider revenues, up from $176bn in 2016. It is projected that wholesale backbone service revenues will grow the fastest between 2016 and 2021 which calls for scalable, timely and cost-effective means to effect bandwidth upgrades.

Alien-Wave Technology: Challenges and Mitigation

Today, the majority of networks deployed worldwide predominantly carry 10G data rate channels. These networks were optimally designed to host OOK modulated channels. With the advancement of carrier-grade optical technology, industry is migrating to more efficient and complex modulated techniques that permit efficient transport of higher data rates and achieve better spectral efficiencies.

Network operators who are exploring ways to augment their network capacity either have to roll out a new overlay network incorporating latest available commercial technologies or explore other means to supplement the existing infrastructure to adopt and absorb some of these latest technologies. AW technology falls in the latter domain.

Operators exploring ways to convert an existing 10G infrastructure into a hybrid network carrying 10G and 100G (or greater-than 100G) coherent channels often come head-on with performance issues on 100G. The 10G environment has a detrimental effect on network performance in the presence of coherent channels. On the other hand 100G is a coherent technology that utilizes phase-shift keying. The power density difference in traditional 10G channels over 100G channels cause them to have greater impact on refractive index (RI) of the transmission media. The changing RI alters the phase of the wavelengths traversing through the transmission media, both of itself (nonlinear effect known as Self Phase Modulation (SPM)) as well as of other wavelengths (nonlinear effect known as Cross Phase Modulation (XPM)). Since coherent technology based 100G channels use phase encoding to transmit user data, they are adversely impacted by phase anomalies. This in turn leads to degraded channel performance both in terms of transmission reach as well as the ability to guarantee error-free transmission. Also, low values of residual dispersion amplify the probability of XPM on 100G. 10G are optically compensated for chromatic dispersion in the network.

A few common methods to mitigate the impact of host 10G on alien 100G are as follows:

1. Better Channel planning: It is advised to place all 10G channels on one end of the available spectrum with 100G channels occupying the other end.
2. Use of Guard bands: It is possible to ensure spectral separation between 100G channels and immediate neighbouring channels thus minimizing the influence of 10G on 100G.
3. Finite Residual Dispersion: The presence of a finite amount of residual dispersion in each of the spans reduces the chances of phase matching condition being satisfied. This reduces non-linear impairments to a large extent.
4. Channel Power Optimisation: One of the primary factors causing non-linear impairments is the high channel power density of 10G. By ensuring that host channels operate at minimum possible power levels, one can limit the non-linear impairments to a great extent.

Tejas Alien-Wave Solution

Tejas' TJ1600 is multi-purpose platform which provides a robust, dense, reliable, proven and cost-effective solution to launch alien-channels over third-party transport layer. With its rich expertise in hosting and operating 100G alien-channels in 10G / 100G third party optical layers, Tejas provides a scalable and cost-optimised solution to help a service provider vastly expand its wholesale business while meet demanding SLAs. The same platform is capable of hosting a variety of technologies (DWDM, ROADM, OLA) and services (SONET/SDH, OTN, Ethernet).

Tejas Network Management System (TejNMS) gives the end users total control, visibility and ability to configure, operate and monitor the alien-waves end to end. All standard network management features like fault management, configuration, administration are fully supported and adhered to in the comprehensive TejNMS software suite.

Tejas Alien Cloud Simulator (TACS) is a unique and home-grown AW design toolkit which helps customers plan and deploy alien-wave channels efficiently. TACS helps operators run pre-deployment simulations and study of the existing physical layer to draw the action plan of field deployment thus reducing the downtime of the network activity, optimising the on-field engineer's efforts and minimising the overall cost and time of deployment. TACS can also be used to identify and optimise the deployed networks to maximize their performance metrics by employing advanced network planning and design services.

Highlights:

- Unique Carrier Phase Recovery technology for addressing non-linear noise, impacting alien waves
- 100G Alien Channel Integration in to brown field 10G Network without any guard band
    - 100G Optics has been tuned to work with 10G Brown field DWDM Network without any guard band between existing 10G and 100G Alien Network
    - Solution well proven across multiple operator across globe
- Common Muxponder Card with 100G, 200G, 400G channel rate with 50Ghz spectral width which can be used an Alien Channel in the existing 50GHz spectral based DWDM Network
- Adaptive Modulation schemes, which can tune the modulation scheme and line rate based on the Optical Layer Parameters

Benefits of Alien Wave Technology

AW technology represents a significant advantage to expand capacity on existing DWDM networks and has several advantages for telecom service providers as listed below:

- Support for Private Channels: AW technology enables direct connection of customer equipment to a third-party DWDM transport layer which was hitherto not technically viable
- Gain Time-to-Market Benefits: AW technology speeds up service rollout since it becomes possible to launch new channels on existing infrastructure without having to make any changes to it or impacting current services.
- Leverage Existing Network Assets: AW technology extends network lifetime by being able to support different modulation formats on a common optical infrastructure.
- Reduce Capital Expenditure: AW technology encourages reuse and sharing of a network and avoids duplication of network builds thus reducing total capital expenditure.
- Realize Best-of-Breed Networks: AW technology opens up the underlying network infrastructure and makes it vendor-agnostic. By reducing single vendor dependency, the carrier is empowered to use best-of-breed technologies during network upgrades.
- Achieve Cost-effective Scaling: AW is the quickest way to multiply bandwidth availability on a DWDM network. Bandwidth can be scaled at a fraction of the cost required in the case of a new network build-out and reduces expensive O-E-O conversions as well.

Tejas AW technology implementation offers the following additional benefits over competitive AW solutions.

- Tejas OTN/SDH equipment supports DWDM transceiver directly on the 10G & 100G Interfaces. High performance FEC is supported on both 10G and 100G interfaces for superior OSNR results. This ensures seamless integration of Tejas Alien channels on existing third-party Alien cloud network.
- Tejas has developed an advanced Alien Cloud Simulator (TACS) to simulate third party DWDM network link budgets and study the impact of running Tejas alien channels.
- Tejas has an advanced laboratory setup with 2000km+ optical fiber cable link with a complex array of DWDM network elements such as in-line amplifiers (ILA's), optical add-drop multiplexers (OADM), reconfigurable OADMs (ROADM) and high-power Raman amplifiers to fully simulate simulate variety of DWDM network scenarios.
- Tejas has carried out several pilot studies and field deployments of its AW technology and has a thorough understanding of the impact of non-linearities in AW implementations. Tejas has a decade-long experience in the AW technology area which mitigates potential performance risks.

Conclusion

Alien Wavelength (AW) technology has emerged as a cost-effective option to progressively scale bandwidth in DWDM networks. Tejas Networks offers one of the most robust, economical and complete AW solutions in the market today that includes an advanced alien cloud simulator (TACS) with comprehensive alien service management from the network management system (TejNMS). Tejas AW technology is a field proven solution that has been widely deployed over multiple third-party DWDM networks around the world.

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