Finisar®

WHITE PAPER

Balancing Performance, Flexibility, and Scalability in Optical Networks

By Ken Falta, Senior Director of Marketing and Craig Cameron, Senior Product Line Manager at Finisar Corporation

The availability of Wavelength Selective Switches (WSS) supporting 100 Gb/s and 400 Gb/s data rates enables network operators to significantly increase bandwidth capacity in DWDM optical networks with substantial CAPEX and OPEX savings. Moving to such higher data rates, however, requires a shift from the continuing trend of implementing narrower optical channel spacing given that data rates beyond 100 Gb/s cannot fit within a 50 GHz channel.

To meet the increasing demands of telecom, CATV and Enterprise operators for lower cost-per-bit transmission capabilities, systems equipment OEMs need technology that can allocate bandwidth flexibly and dynamically to meet evolving performance and capacity needs without requiring new equipment deployments. In this way, systems equipment OEMs can enable their customers to maximize efficiency as well as introduce new services and capabilities that give them a competitive edge.

Why Increasing Spectral Efficiency is Important

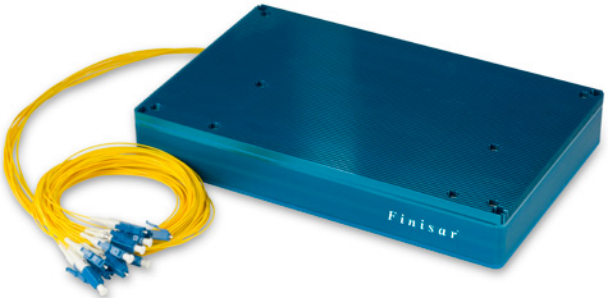
In the early days of DWDM systems, the bandwidth of an optical fibre was considered to be effectively infinite, given the relatively low data rates which were then in use[1] and that capacity could be increased simply by adding additional DWDM channels or by raising the transmission speed (e.g., from 2.5 to 10 Gb/s). Today, the industry has moved from 40 x 100 GHz channels per fibre to 80 – and most recently to 96 – 50 GHz channels which has more than doubled the maximum capacity over the same fibre. Furthermore, increasing channel data rates from 10 Gb/s to 40 Gb/s and now 100 Gb/s provides a further 10x increase in capacity.

However, as we have now reached the limit of how much information can be realistically transmitted within a 50 GHz channel – 100 Gbits/sec = 2 Gbits/sec/Hz in a 50 GHz channel – the industry needs to revisit how optical spectrum can be used most effectively to increase the overall spectral efficiency.

For example, networks still using a 100 GHz channel to carry a 100 Gb/s signal can achieve greater efficiency by migrating to a more narrow 50 GHz channel. Alternatively, efficiency can be increased by widening the channel. While a 400 Gb/s signal cannot fit within a 50 GHz channel, it can fit within a single 100 GHz channel for a spectral efficiency of 4 Gbit/sec/Hz to achieve twice the efficiency across the same spectrum.

Dynamic Channel Bandwidth

The challenge for network operators when deploying new equipment is to do so in a flexible manner that supports both existing and future data rates through the ability to provision both nar-



DWP Wavelength Selective Switch

EWP Wavelength Selective Switch

[1] For example, see "TELECOSM: How infinite bandwidth will revolutionize our world" by George Gilder, 2000.

row and wide channels. MEMs-based WSS devices, for example, are fixed in how they implement channel width. This means that a MEMs-based WSS deployed with 100 GHz channels cannot later be reconfigured for 50 GHz channels to support higher channel density as the network grows. Similarly, a MEMS-based device deployed at 50 GHz cannot later be reconfigured for 100 GHz channels to scale to the higher levels of efficiency that 400 Gb/s offers.

Understandably, companies that are just starting to deploy 100 Gb/s may not yet be concerned with the details of how to deploy 400 Gb/s. However, even a state-of-art MEMs-based WSS with 50 GHz channel width will be unable to support standards like 400G that require 100 GHz channel spacing. Fixed channel spacing inflexibly locks the capacity of the network, leading to more frequent and higher infrastructure investment.

Adjustable Channel Spacing using LCoS Technology

Ideally, equipment needs to be flexible enough to evolve with the changing demands placed upon the network, thereby maximizing ROI and minimizing per-bit transmission costs. Finisar's Wavelength Selective Switches (WSS), for example, are built upon Finisar's innovative Liquid Crystal on Silicon (LCoS) technology and provide the industry's most flexible WSS modules with features such as selectable channel spacing to a granularity of 12.5 GHz, dynamic per-channel bandwidth control, and per port/per channel attenuation control.

The Dynamic Wavelength Processor (DWP) platform of WSS modules supports switching up to 20 ports while Edge Wavelength Processor (EWP) WSS modules offer up to 4 ports in a small form factor ideal for low-cost network edge applications. Both platforms are compliant with Flexible DWDM grid per ITU G.694.1 and support data rates of 10G, 40G, 100G, 400G, and future high-speed applications. Customer trials have shown that Finisar's WSS modules are capable of long cascades (over 30 WSS) while maintaining reliable 100G performance.

Finisar's DWP range of WSS supports adjustable channel spacing with no impact on performance. This gives network operators the flexibility to support legacy 10 Gb/s connections on both 50- and 100 GHz channel spacing, migrate to 100 Gb/s using 50 GHz, and support the many 100 GHz devices which are already available for 400 Gb/s, all without needing to replace the WSS or the equipment into which it is integrated. In addition, there is no need to overbuild networks today to be able to accommodate 400 Gb/s or higher speed data rates tomorrow, nor will there be a need to re-provision networks as new data rates at different frequencies become available that take advantage of the spectral efficiencies of new flexible grid technology.

Flexible Grids for Higher Spectral Efficiency

While no one knows how quickly technology will advance, it is clear that being locked into the 50 and 100 GHz ITU grids will prevent network operators from being able to deploy emerging technologies in a timely and cost-effective fashion. Flexible grid technology provides a reliable means for systems equipment OEMs to enable greater spectral efficiency no matter how technology advances because it can support more narrow channel spacing while maintaining data rates or, where appropriate, wider channels to accommodate higher data rates.

For example, advances in technology may soon enable a 100G link to fit within a 37.5 GHz channel or a 400G link within an 87.5 GHz channel. The efficiency gains that could be achieved in this way are significant: at 37.5 GHz, four 100G links could be deployed where only three were before for a 33% increase in bandwidth.

There is also the issue of superchannels to consider. Limiting channel spacing granularity to 50 GHz will likely be too restrictive; for example, a particular superchannel may be more efficient at 125 GHz than either 100 GHz or 150 GHz.

The ITU has recognized the need for flexible grid technology to support greater spectral efficiency for DWDM applications with less equipment and at a lower cost. With the new ITU G.694.1 standard, systems can allocate frequency beyond the 50 and 100 GHz ITU grids to optimize each channel for the bandwidth requirements of the particular bit rate and modulation scheme.

To be compliant with the Flexible DWDM grid definition in G.694.1, equipment needs to be able to support channel spacing granularity of 12.5 GHz. Systems that cannot support 12.5 GHz granularity will be unable to provide the substantial CAPEX and OPEX savings possible with flexible grids.

Flexible grid technology like Finisar's Flexgrid™ WSS modules enable network administrators to easily reallocate spectral resources and optimize channel spacing to balance the needs of legacy and new equipment with a single WSS. In addition to being fully compliant to the ITU G.694.1 standard, devices integrated with one of these WSS modules can claim 400 Gb/s compatibility as well. They will also be able to accommodate next-generation standards, such as those being developed to support data rates up to a terabit per second, thus guaranteeing long operating life for equipment and a high ROI.

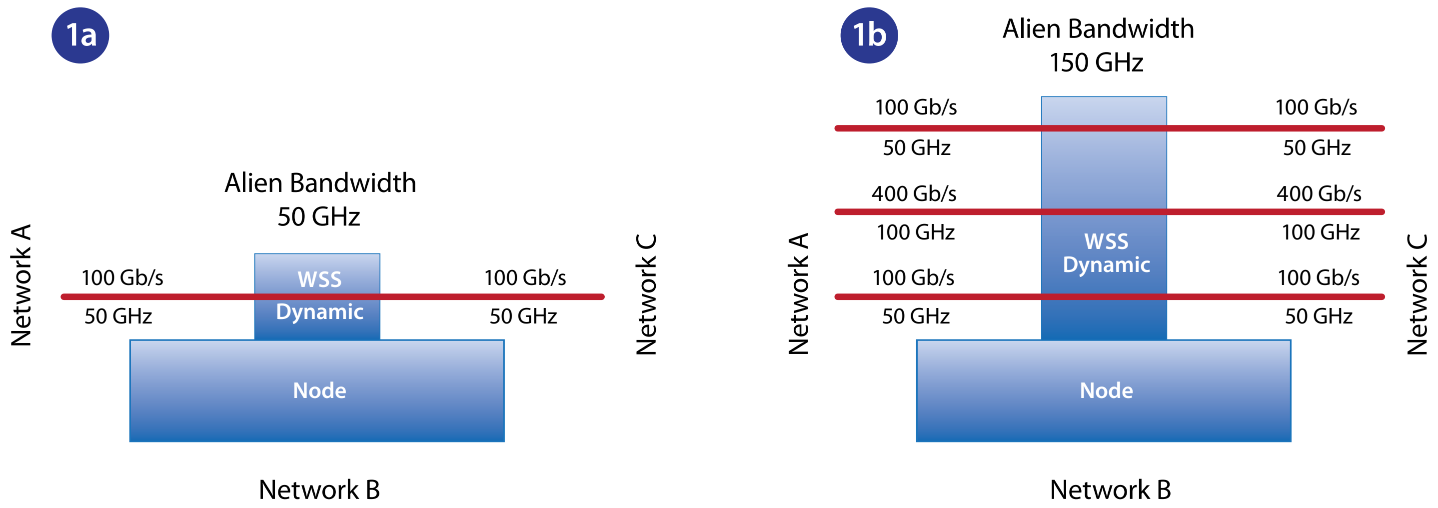


Figure 1: The benefit of Flexgrid with regard to the management of alien wavelengths is that a portion of spectrum can be allocated to alien wavelengths by systems within network B without knowing anything about the individual wavelengths passing through (such as their center frequency or spectral width). In legacy networks, only wavelengths that matched the channel grid of network B could be accommodated.

Physical limitations in MEMS technology, specifically the gap between mirrors, restrict channel spacing granularity of MEMs WSS devices to 50 GHz. While enabling compliance to current 50 and 100 GHz ITU grids, this limits MEMs WSS products to being selected either for efficiency or scalability but not both. For example, provisioning 50 GHz channel spacing offers the best spectral efficiency for implementing 100 Gb/s but does not support 400 Gb/s in the future. Alternatively, selecting 100 GHz spacing will provide the best scalability to 400 Gb/s but at the cost of 100 Gb/s efficiency today.

With Finisar's LCoS WSS platforms, network operators can have both the efficiency of 50 GHz for 100 Gb/s as well as the scalability to switch to 100GHz channels to support 400 Gb/s. The result is significant CAPEX savings in terms of time and cost. In addition, the network will also be ready to support variants such as 400G over 87.5 GHz or 100G over 37.5 GHz once these technologies are available.

New Services and Increased Revenue

The ability to dynamically allocate spectral resources and maximize efficiency with narrow granularity is enabling simpler management of alien wavelengths which are expected to become more common in network deployments. With Flexgrid™ technology, a transparent connection between two networks can be opened (see Figure 1a). The WSS can be reconfigured to dynamically accommodate a block of spectrum without any new equipment required (see Figure 1b). Note too that the intermediate network between the two networks doesn't have to know anything about the signals traveling across it, whether they are four 50 GHz channels, two 100 GHz wavelengths, or a mix of different frequencies. This approach provides the most flexibility at the lowest cost and latency.

Another important application is the ability for network operators to increase the spectral efficiency of their network and then generate additional revenue from their newly available bandwidth by leasing it. Flexible grid technology becomes a critical factor in supporting bandwidth leasing in a simple manner at the lowest cost. When channel spacing is fixed, the leased bandwidth has to be allocated to match the physical constraints of the network. If either network operator wants to scale the amount of bandwidth being supplied, new transmission equipment may be required. Changes in capacity will also have to be allocated in 50 or 100 GHz slices if MEMs-based WSS are being used, depending upon what equipment is already in place.

With flexible grid technology and adjustable channel spacing, the amount of leased bandwidth can be dynamically reallocated in slices as narrow as 12.5 GHz to meet changing capacity demands without requiring new equipment. In addition, systems are capable of supporting wide transparent channels greater than 200 GHz with the lowest latency. This enables network operators to support a variety of types of channels, including superchannels, without having to know the specifics of what type of data is being transported.

With the acceptance of the G.694.1 standard, it is clear the industry is removing 50/100 grid limitations and moving to 12.5 GHz channel spacing. Flexible grid spacing technology creates new revenue opportunities for systems equipment OEMS and network operators that have not been possible before. Network operators will also be able to create the most efficient networks possible with no performance trade offs that scale elegantly to meet future capacity requirements.

As a consequence, it is no longer a long-term strategy to support flexible grid spacing but rather a crucial part of deploying cost-effective networks today. In this way, networks can dynamically adapt to not only ever-increasing capacity demands but also evolving standards and take full advantage of higher spectral efficiency as new technology becomes available.

Finisar®, with its industry-leading WSS modules based on LCoS and Flexgrid™ technology, provides systems equipment OEMs with the performance, dynamic flexibility, and scalability required for both today's and tomorrow's networks. To see how Finisar's Flexgrid technology can future proof your network, use the QR code or visit qrs.ly/wl1gp4h.

For more information about Finisar, visit our website at www.finisar.com

Finisar®
1389 Moffett Park Drive
Sunnyvale, CA 94089, USA
Phone (US Toll Free): +1 888.746.6484
Phone Intl: +1 408.400.1000
Email: sales@finisar.com
www.finisar.com