BATTLE OF THE BANDS

Fixes For Looming Optical Network Traffic Jams?

As is widely reported, the amount of traffic carried over the world's optical fibre networks has been growing on some routes at a prodigious rate in recent years, and the expectation is that the volumes involved should only get larger in the future. In that eventuality it's likely that the development and introduction of effective measures to circumvent conceivable optical system traffic jams will become more commonplace, writes veteran tech journalist **John Williamson**.

Daryl Inniss, optical fibre and device expert with a focus on commercialising technologies, says that, on the fibre side, there is industry debate on how to support traffic growth at some 30% per year. Inter alia, Inniss sits on the European Conference on Optical Communications (ECOC) Market Focus Committee.

Fleshing traffic volumes out, and citing his own company's 'Global Network Traffic 2030' report, Dave Brown, Senior Product Marketing Manager, Line Systems, Nokia Optical Networks, says overall global network traffic demand is expected to reach between 2,443 to 3,109 Exabytes per month in 2030. This is around 100 times the total monthly Internet traffic generated in 2012

WAVELENGTH COMBINATIONS?

One possible capacity augmentation strategy is to use different or additional wavelengths to the C-band. "The thought is by 2030 the industry will need more bandwidth per fibre; higher transmission rate in the C-band is not sufficient," judges Inniss. Referring to potential C- and L-band combinations, he observes that transmission lines have to be provisioned with hardware to accept both C- and L-band transponders. "While the line may not use L-band today, the necessary hardware is going in so that it is easy to increase capacity," Inniss contends.

The C-band currently dominates DWM systems in the trans-national submarine cable arena. But it's reported that, so far, the only extant C- and L- band subsea system is Pacific Light Cable Network. There could be others in the pipeline, but Howard Kidorf, Managing Partner at Pioneer Consulting, reasons that C+L, is not the preferred method of the undersea system suppliers for increasing the capacity of an undersea cable. "Space-Division Multiplexing (SDM) – i.e. just more fibre and amplifiers - and to a lesser extent multi-core fibre (MCF), are preferred as the engineering is more straightforward and by some metrics, the capacity is greater," reckons Kidorf." Putting more fibre in the cable is a relatively small additional cost to a cable."

TERRA IS FIRMER, THOUGH

The C- and L-band pairing picture is somewhat different in the long-haul terrestrial cable sector.

As described by Brown, many of his company's Communications Service Provider (CSP) customers are utilising spectrum-based C+L-band DWDM solutions in terrestrial networks to effectively double the capacity per fibre pair and avoid the cost of leasing additional fibre pairs.

"Although commercial C+L-band solutions have existed for several years, the recent availability of more highly integrated and application-optimised line system solutions has enabled a broader adoption of C+L in metro and long-haul networks by CSPs (and) cable operators, as well as enterprises," adds Brown.

NOT A WALK IN THE PARK

However, the use of L-band and combination C- and L-band frequencies isn't necessarily a slam dunk. "For better or worse now there's been a huge amount of investment within the C-band. And like with any technology, you get economies of scale. So you now have extremely cost effective solutions within the C- band," admits Rob Shore, Senior Vice President of Marketing at Infinera. "L-band is much, much less utilised because you need a completely different type of amplifier to amplify frequencies in that range."

Kidorf points out that the L-band is not disadvantageous, per se, but the need to manage C-band and L-Band introduces additional design constraints on equalisation, cross-talk, fibre testing and many other areas. "Even after this work, the separate L-band amplifier in the repeater still requires space and electrical power," he comments. ."L-band amplifiers are not the most straightforward way to maximise the number of Terabits transmitted per Watts of electrical power."

Kidorf clarifies that these caveats apply to both submarine and terrestrial to some extent, but are a much larger issue with submarine due to the limitations on space and deployment complexity. The considerations for terrestrial application are extremely small by comparison.

Cost and earnings are, of course, pivotal considerations in shaping which proposed capacity enhancement

mechanisms will be viable and which won't. Here it's worth repeating the remarks of Kidorf that, despite 30% (or more) growth rate of required capacity on some subsea routes, this is accompanied by a decline in the price charged for capacity. "There is not a fantastic growth rate in the total money exchanged for undersea traffic, but, for now, we are getting more Gbit/s for the same money."

At the same time, C- and L-band may not always be friendly neighbours. "There are some interplays that happen when you try to put C- and L-bands on the same fibre where the C-band signals actually lose power to the L-band signals. You get this kind of Raman effect where the L-band signals steal power from the C-band" notes Shore.

It's also the case that C- and L-bands are not the only available wavelengths in town. Inniss says that the S-, E-, O- and U-bands are being assessed to understand the challenges. "WDM can scale beyond the C and L-bands," he acknowledges." But, again, there are downsides here. "Cost is a big challenge," allows Inniss. "Transponders, amplifiers, and ROADMs are needed for other bands. They are not readily available today."

OTHER ROUTES OUT OF OPTICAL GRID-LOCK

A number of other avenues aimed at side-stepping would-be optical cable capacity log jams are being implemented or explored. As well as the SDM and multicore fibre instanced by Kidorf, one of Nokia's takes on maximising spectral utilisation in subsea transmission is what is termed 'water filling'. As explained by Chris Janson, Senior Product Marketing Manager, Subsea Systems, Nokia Optical Networks, water filling makes very fine adjustments in link baud rate to optimise spectral efficiency, line capacity, and optical span reach. He observes that for a fixed bit rate, shaped modulation format, and FEC scheme, you can adjust the baud rate (bit rate per symbol on the modulation constellation) and realise a trade-off in link capacity versus span length.

"By adjusting the baud rate in fine increments, roughly around 0.1 Gbaud, system flexibility increases to operate at a desirable span length for a given capacity, and within a desired optical channel plan," he offers. "In subsea cable systems, this allows the operator to increase the number of deployed channels (and the resulting total lit capacity), increase system link margins, or reduce the number of operating optical transponders."

Infinera's Shore is a supporter of turning up additional fibres in parallel. "Rather than a single pair of fibres between two locations where you expend a lot of energy to maximise the capacity of that single fibre pair, you use multiple fibre pairs between locations," he asserts. "This enables network operators to focus more on using cost and power efficient solutions."

Shore reasons that with this approach, spectrum becomes a much lower premium. "The value of spectrum is lower enabling people to better leverage much more cost-effective optical engines that maybe aren't as spectrally efficient." This, he believes, paves the way for increased use of pluggable coherent optical engines. "This class of optical engines are extremely cost effective, and extremely power efficient, but are generally quite a bit less spectrally efficient." He likens the difference between pluggables and the embedded optical engines historically designed to maximise spectral efficiency as the difference between thumb drives and computer hard drives.

WHAT IS MORE?

There's a spectrum of opinion about what's next in terms of how to head off potential optical cable capacity short-falls. Janson believes the trends to consider are the development of advanced fibre cables, including issues surrounding inherent fibre impairments and practical, physical limitations of SDM. "It is also worth watching future developments in SLTE coherent detection and signal processing as they will impact the capacity capabilities of future systems."

Inniss predicts that it's likely that operators serving different market segments will, at different times, adopt different capacity boosting solutions for these segments. "Thinner fibre and MCF, for example, will go into subsea first," he calculates.

According to Kidorf, one trend is to reduce the power and space required for undersea amplifiers and to increase the electrical power-carrying capability of the cable. "I also look forward to an increased eco-system for multi-core components (a multi-core amplifier?) so that N-core fibre does not require N independent amplifiers in the repeater,"

SUPERSIZING THE C-BAND

Over time, the optical networking industry has extended the capacity of C-band operations. According to Infinera literature, the deliverables of the original C-band (4 THz amplification giving 80 channels at 50 GHz spacing) were upped in Extended C-band to a flat gain of 4.8THz, giving 96 channels at 50GHz. More recently advances have been made in C-band amplifiers, extending the effective range to about 6.1 THz and offering up to 120 channels 50 GHz. These solutions typically referred to as Super C-band.

"The benefit of this approach is that network operators can get 25 to 30% more capacity while still using a single set of amplifiers, filters, and ROADMs," comments Shore. "Additionally, tuneable lasers that can now be tuned across the entire 6.1 THz of spectrum."

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