800G technology: Does double capacity mean twice the performance?

OMDIA

Brought to you by Informa Tech

Contents

Introduction

Optical networks are evolving to support the insatiable appetite for information driven by video streaming , mobile applications and the digital transformation of businesses utilizing the cloud. Several data rich apps are coming online: 5G upgrades with millions of users demanding high definition content and video anywhere and anytime, distribution of 4K video and gaming. Information is the currency of business and we expect the demand for it will continue to grow over the next 5 years at a rate similar to what we have seen over the past 10 years. Optical networks transport the vast majority of this information and to keep up, they will need to continue to add capacity.

To keep pace with network bandwidth demand while reducing cost, operators have traditionally moved to higher data rate transceivers. Looking at the first coherent decade, in 2010 state of the art was 10Gb/s direct detect full grid tunable modems and now in 2020 leading vendors are conducting field trials on 800Gb/s coherent modems. This is an 80x increase in data rate in 10 years which is very impressive. Moving forward, the industry is facing some fundamental limitations, including the Shannon limit and a slowing of Moore's law. Because of these challenges, we expect that amplified spectrum will increase in value and solutions that maximize the capacity and efficient use of the amplified spectrum will be rewarded.

For 800G solutions, does 2x the capacity over 400G give twice the performance? The answer is both yes and no depending on the parameters you are comparing. The more important question is: what practical benefits do new 7 nm coherent DSPs and higher-speed coherent optics and ADC/DACs provide in practical networks? In brownfield optical transport networks, the distance between nodes is defined by physical locations. Any new coherent modem technology needs to be able to transmit error free, setting a minimum reach requirement that varies by application and network.

400G+ multi-haul coherent transceivers

Transitioning to higher data rate coherent modems is enabled in two ways:

- 1) Using higher-order modulation formats to increase the spectral efficiency.
- 2) Increasing the baud rate of the carrier using higher speed electronics and coherent optics.

Each of these has advantages and disadvantages that depend on the requirements of the application and network.

Higher order QAM modulation has the advantage of using amplified fiber spectrum more efficiently but it comes at a cost. Higher order modulation formats are more susceptible to noise, resulting in shorter fiber reach. For example, moving from 8QAM to 16QAM at the same baud rate results in 2 times the capacity in the same spectrum, but the reach is reduced by a factor of 4. On the other hand, doubling the baud rate from 32 to 64 Gbaud, and using the same modulation format doubles the data rate while achieving fiber spans of ~ 90% the reach of the lower baud rate when using optimized DSP algorithms and appropriate signal levels. The downside of moving to higher baud rates is that the signal width increases with increasing baud rate and the associated channel width needs to accommodate this increase.

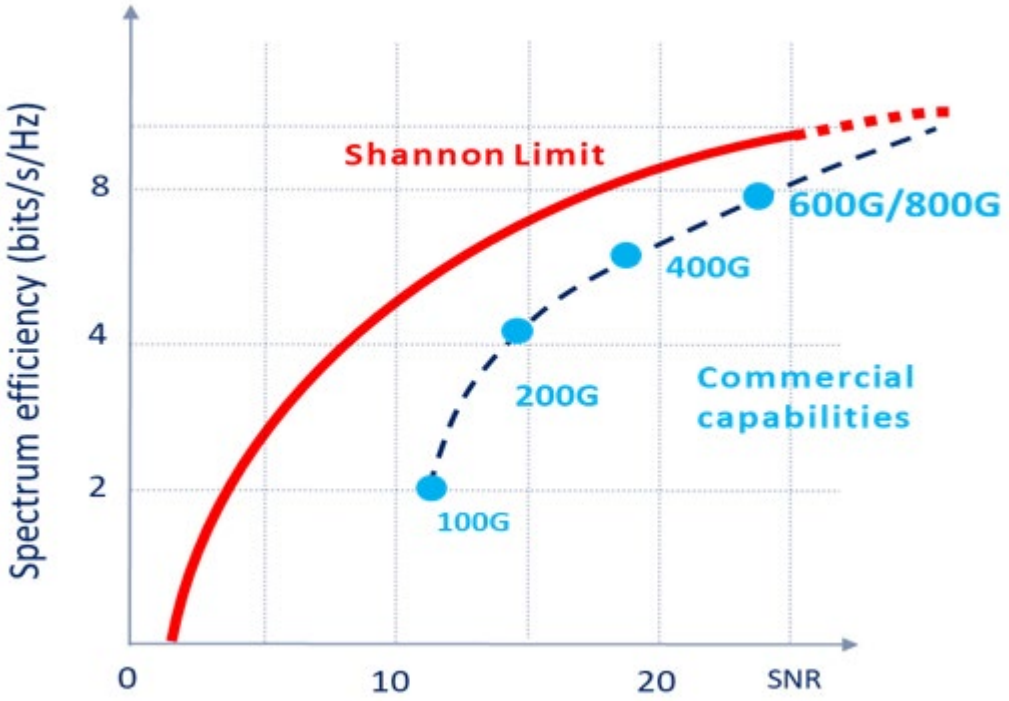
For metro, regional, long haul and subsea applications, the clear path forward is to increase the baud rate but use the most spectrally efficient modulation format possible for each network node. Multi-rate coherent modems can be configured to optimize, node capacity, network capacity, reach and other important parameters.

New 7 nm DSP technology coupled with higher speed electronics and optics in new coherent modems holds promise to significantly improve performance and capacity at reach by increasing the baud rate up to 95 Gbaud. The extra computational power in these DSPs is being used to provide higher coding gain, support probabilistic constellation shaping (PCS), high performance non-linear compensation and other improvements, which extend reach for all modulation formats. Multi-rate coherent modems enable networks to adjust data rate, modulation format, baud rate, signal levels and channel widths to optimize the performance of each network node. Fixed 100G coherent modems are mature products and many network operators are moving to multi-rate solutions

Shannon limit increases in value amplified fiber spectrum

If the pipe isn't big enough, use a bigger one. Commercial technology is near the Shannon limit defining the amount of information that can be transmitted in a slice of spectrum per unit of time. We are now only ~1.5 dB from the limit with the latest coherent modem technology and there is very little additional capacity available in the extended C band. Bandwidth demand continues to expand at about 30% per year, effectively doubling every 2.5 years and we are running out of amplified spectrum in many networks. Networks capacity expansion from data rates and spectral efficiency will be incremental going forward. New thinking and direction are needed to continue to meet network bandwidth demand created by our information society.

Exhibit 1: Commercial performance approaching the Shannon limit



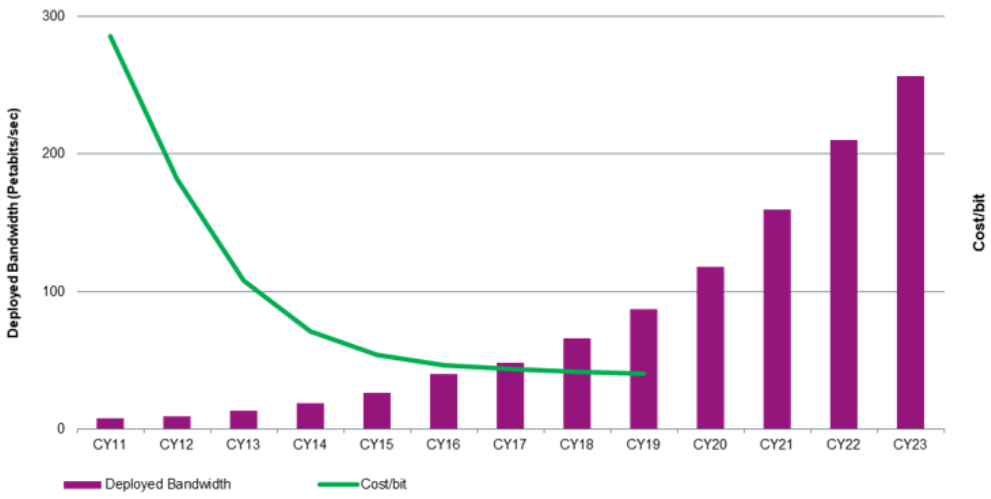
Source: Huawei – 2020

A complementary approach is to increase the amount of useful fiber spectrum in DWDM networks by expanding C-band and using L-band. Doing so promises to increase the amplified spectrum over 200% over that of the extended C band. We expect this approach to be well received by service providers, giving them the tools to delay lighting new fiber in brownfield networks.

Next generation fiber infrastructure needs to both expand amplified spectrum and use this spectrum as efficiently as possible, delaying the need for new fiber. Next generation flexible grid based CDCF ROADMs will play an important role improving the use and management of fiber spectrum in future DWDM networks that move away from fixed grid to use flexible grids needed by 400G+ coherent modems.

In the first 5 years of the coherent era from 2011–2015, we were able to get huge gains in capacity and reach through spectral efficiency, polarization multiplexing, higher speed electronics and more capable DSPs. This provided about a 30% per year reduction in the cost per bit and kept spending flat as it matched the pace of increasing network bandwidth demand.

Exhibit 2: Deployed bandwidth history and forecast cost per bit



Source: Omdia – 2020

From 2016 on we have seen a slowing of the cost per bit reductions but growth rates for network bandwidth remain around 30% per year. This has resulted in increased spending on optical transport equipment from 2016–2019. To combat this, the industry is now moving to develop specialized solutions for higher volume applications to optimize value and reduce cost.

The first of these products with broad industry support is 400ZR, specifically developed for point-to-point unamplified links used for data center interconnects. We expect to see more specialized products introduced to market to provide application-oriented, cost-optimized solutions.

Data rich applications drive network growth

Coherent modem deployment can be used as a proxy for data center interconnect, metro, regional, long-haul and subsea optical network growth. Omdia tracks the use of these transceivers for trend analysis and to forecast future use. During the coherent era, annual growth rates have been between 25–40% CAGR, with some year to year and regional variation. Our conservative forecast model projects future growth rates between 24% and 34% from 2019 to 2023 with approximately 250Pb/s in new capacity deployed in 2023. Over this same period, we forecast the CAGR of 400G+ coherent modems to be greater than 100%. By 2023, Omdia forecasts over 50% of the new capacity deployed will use 400G+ transceivers as networks adopt higher data rates to increase capacity and reduce cost.

The role of SDN and network automation

Service velocity, cost, flexibility and capacity are key differentiators for optical networks as the industry transitions from static, fixed grid to dynamic, flexible grid architectures and service providers have an opportunity to differentiate services and increase connectivity using these new tools afforded by flexible grid ROADMs and multi-haul coherent modems. Effective use of these tools creates additional complexity in network management as modulation formats, baud rates and routes need to be carefully selected, monitored and controlled to achieve desired reach, spectral efficiency, noise characteristics, latency and other parameters. We believe managing this complexity will be a key driver for the optical network automation supported by SDN control and orchestration.

It is insightful to compare DWDM networks with radio networks in cellular applications. Radio networks employ variable modulation formats and data rates which are dynamically controlled to optimize link parameters such as quality of service, reach, spectrum, latency and other parameters using adaptive technologies. 200G–800G+ multi-haul coherent modems offer similar flexibility and we expect increased use of adaptive technologies. Automated control of flexible grid CDC-ROADMs will be used to manage, add, drop and groom traffic in telecom and web scale applications.

Bottom line

Optical transport networks have been increasing data rates to scale network bandwidth over the past 45 years. With the latest coherent modem technology, commercially available transport technology is now only 1.5 dB from the Shannon limit. Going forward, gains in spectral efficiency will be limited and performance improvements will be more incremental, especially longer reach applications. The most cost-effective path forward is to increase capacity by increasing the baud rate and employing the additional capabilities that new DSPs and coherent optics provide.

Coherent modem technology based on 7 nm DSPs and higher baud rate coherent optics has very impressive performance and capacity. It will push high capacity networks very close to the Shannon limit, almost at the capacity limit in the extended C band. We expect that L band and further expansion of the amplified spectrum will be a top priority for operators of high capacity routes. We also expect that CDC ROADMs supporting flexible grids and having the capability to dynamically allocate spectrum will become instrumental tools for managing and grooming network traffic to more efficiently use precious amplified spectrum.

The question remains for new 800G solutions, does twice the capacity mean double the performance compared to current 400G products? The answer is complex and depends on the specific network and the parameters considered. For important parameters like capacity at reach, total capacity and the number of coherent modems required for a given network, the answer is emphatically yes. When considering other parameters, including extended reach and power dissipation, the improvements are impressive but more incremental, in the range of 25% to 35%.

We expect that the performance improvements, expanded capacity, and more cost-effective solutions provided by 7 nm DSP, higher speed electronics and coherent optics are strong motivation for web-scale operators and service providers to begin deploying these products in volume when they are ready for commercial release. Because they require upgrades to the fiber infrastructure supporting wider and variable width channels, network upgrades will need to precede their deployment. This will likely temper the adoption rate and focus it on high capacity longer reach network nodes.

To learn more

Watch this free webinar

"800G technology: Does double capacity mean twice the performance?"

presented by Omdia and our partners

The webinar can be accessed at: https://bit.ly/2uDXx7M

For additional Omdia events, visit:
https://technology.informa.com/Events

Follow the conversation @OmdiaHQ

Author

Timothy Munks
Principal Analyst, Optical Networking Technology
Timothy.Munks@omdia.com

Get in touch

www.omdia.com
askananalyst@omdia.com

Omdia consulting

Omdia is a market-leading data, research, and consulting business focused on helping digital service providers, technology companies, and enterprise decision-makers thrive in the connected digital economy. Through our global base of analysts, we offer expert analysis and strategic insight across the IT, telecoms, and media industries.

We create business advantage for our customers by providing actionable insight to support business planning, product development, and go-to-market initiatives.

Our unique combination of authoritative data, market analysis, and vertical industry expertise is designed to empower decision-making, helping our clients profit from new technologies and capitalize on evolving business models.

Omdia is part of Informa Tech, a B2B information services business serving the technology, media, and telecoms sector. The Informa group is listed on the London Stock Exchange.

We hope that this analysis will help you make informed and imaginative business decisions. If you have further requirements, Omdia's consulting team may be able to help your company identify future trends and opportunities.

Copyright notice and disclaimer

The Omdia research, data and information referenced herein (the “Omdia Materials") are the copyrighted property of Informa Tech and its subsidiaries or affiliates (together “Informa Tech”) and represent data, research, opinions or viewpoints published by Informa Tech, and are not representations of fact.

The Omdia Materials reflect information and opinions from the original publication date and not from the date of this document. The information and opinions expressed in the Omdia Materials are subject to change without notice and Informa Tech does not have any duty or responsibility to update the Omdia Materials or this publication as a result.

Omdia Materials are delivered on an “as-is” and “as-available” basis. No representation or warranty, express or implied, is made as to the fairness, accuracy, completeness or correctness of the information, opinions and conclusions contained in Omdia Materials.

To the maximum extent permitted by law, Informa Tech and its affiliates, officers, directors, employees and agents, disclaim any liability (including, without limitation, any liability arising from fault or negligence) as to the accuracy or completeness or use of the Omdia Materials. Informa Tech will not, under any circumstance whatsoever, be liable for any trading, investment, commercial or other decisions based on or made in reliance of the Omdia Materials.