IP WAVE

Communications Software
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ribbon

No Limits Metro-Regional 800G and Long Haul 400G Optical Transport

White Paper

The Gold Standards for Modulation

The principal line rates for optical transmission over the wide area network need to be in multiples of 400G to transport ubiquitous 100bE and growing 400GbE services traffic. This means rates of 400G, 800G, and even 1200G where achievable. Figure 1 shows how we arrive at these line rates.

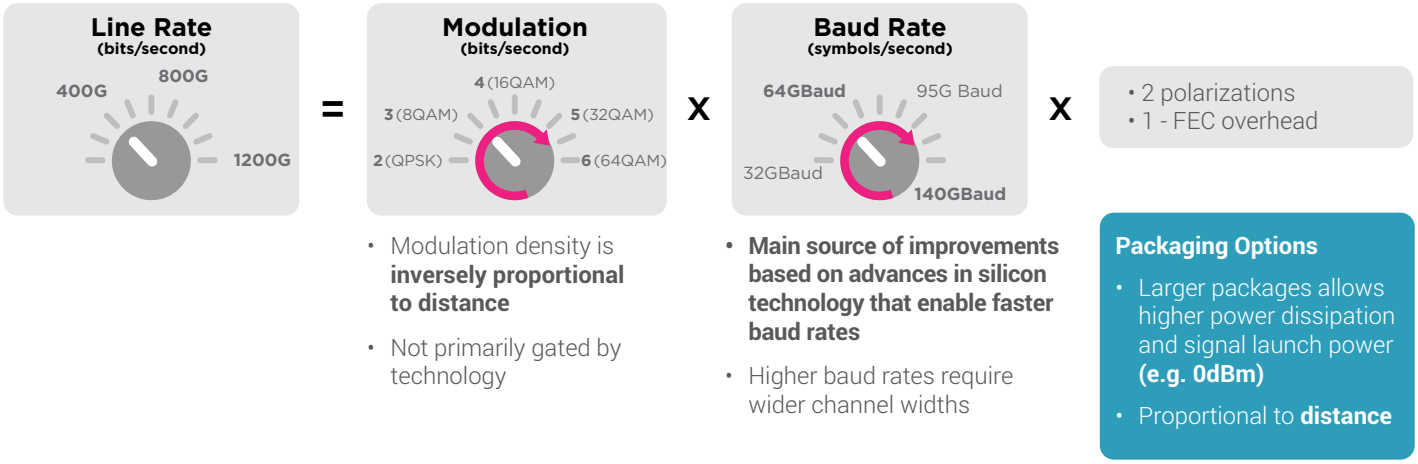

Figure 1 – Technical Framework for Optical Transport

To achieve these line rates for metro-regional and long haul applications, a fundamental parameter to consider is modulation. Modulation is inversely proportional to distance based on physics. Denser modulations means shorter distances, and less dense modulation means longer distances. Moreover, technology can't really improve modulation effectiveness beyond recent advances using probabilistic constellation shaping. For optical transmission, the industry broadly recognizes two modulations as **gold standards: 16QAM (4 bits/symbol) for metro-regional applications, and QPSK (2 bits/symbol) for long haul applications.** When transmitting with these modulations, the entire metro-regional and long haul applications spaces, respectively, can be covered.

Using the equation, it is straightforward to calculate what minimum baud rates are required to support these modulations for various multiples of 400G line rates. (The calculations use 20% FEC overhead.) The results in Table 1 are the basis for Ribbon's optical transport solutions strategy.

	Metro-Regional (16QAM)	Long Haul (QPSK)
400G line rate	**>62.5 Gbaud**	**>125 Gbaud**
800G line rate	**>125 Gbaud**	**>250 Gbaud**

Table 1 – Minimum Baud Rates

Capacity-Reach and Cost-Power Optimized Solutions

The highest levels of wavelength launch power used in commercial optical transport networks is 0dBm or 1mW. (0dBm is used here as the base value for high power transmission, which in practice can range up to 3dBm or 2mW.) This power is required to transmit a wavelength without regeneration across multiple hops in Metro-Regional CD/CDC ROADM networks and in Long Haul applications.

Ribbon provides two types of coherent optical transport solution using 0dBm wavelength launch power, illustrated in Figure 2.

- **Capacity-Reach Optimized** – These solutions maximize the spectral efficiency for any distance and fiber condition. They are used in most long haul applications to squeeze every bit of capacity from a channel, and can also be economical in high-density metro applications. They rely on proprietary transceiver technologies that maximize the bit rate by programmatically creating the optimum mix of baud rate, modulation scheme, and channel width. These proprietary transceivers are not absolutely constrained by size and electrical power in order deliver higher performance.

- **Cost-Power Optimized** – These solutions optimize for lower cost and electrical power, while providing strong enough performance for most metro applications, and as the technology evolves, also for regional transport. They rely on multisource pluggable transceivers that implement industry agreements from organizations like the OpenROADM MSA that emphasizes multisource interoperability, as well as OpenZR+ and the OIF. There are three main types of pluggables for coherent optical transceivers with different size and power dissipation constraints, enabling different levels of performance:

  - QSFP-DD 14cm3 (18.4×8.5×89.4mm) / ~25W
  - OSFP 29cm3 (22.6×13.0×100.4mm) / ~30W
  - CFP2 55cm3 (41.5×12.4×107.5mm) / ~25-30W

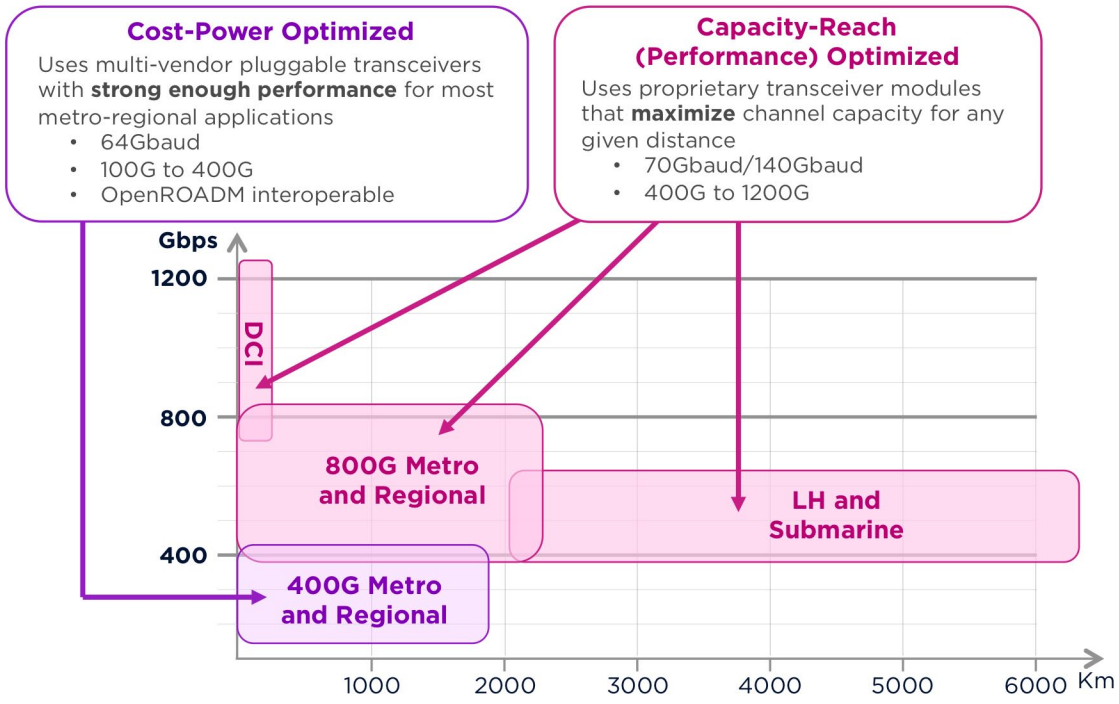

Figure 2 – Two Types of Ribbon 0dBM Coherent Optical Transport Solution

Ribbon Transceiver Technology Roadmap

Figure 3 summarizes Ribbon's roadmap of coherent transceiver technologies supporting 0dBM wavelength launch power.

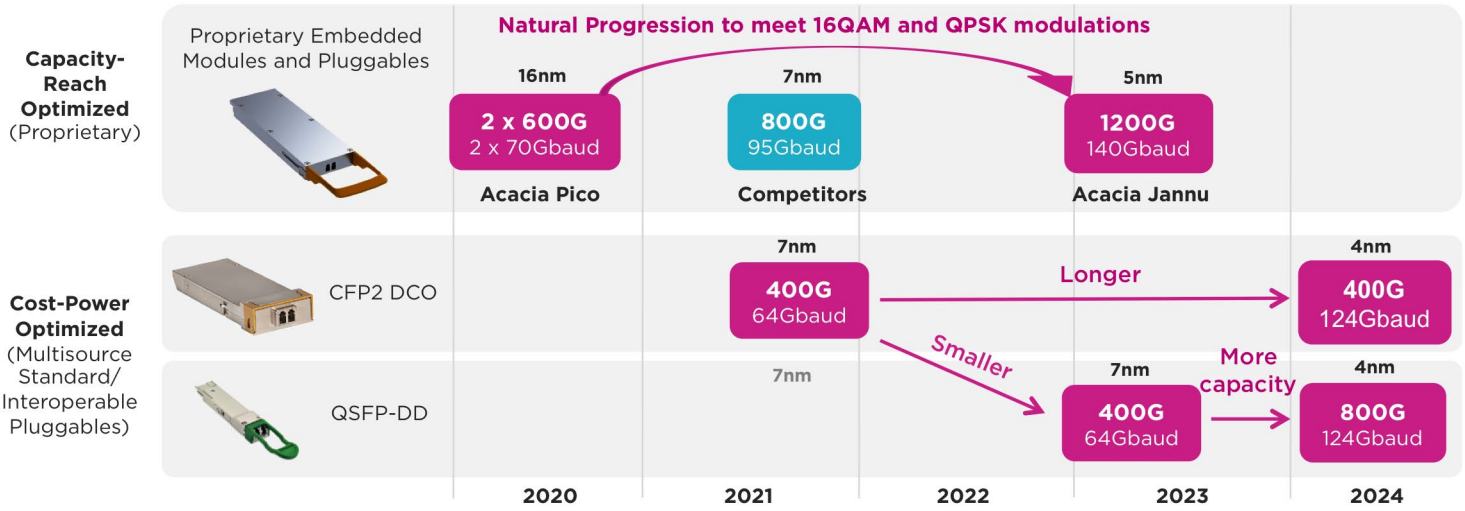

Figure 3 – Ribbon Roadmap of 0dBm Coherent Transceiver Technologies

For capacity-reach optimized solutions, Ribbon is progressing from using Acacia's Pico to their Jannu transceiver technology. Based on state of the art 5nm silicon, Jannu operates at an industry-leading 140Gbaud with a maximum line rate of 1.2T. Jannu delivers with a single wavelength where Pico required two, and in smaller more economical packaging. Critically, it is able to transmit at 800G using 16QAM for all metro applications, and at 400G using QPSK for all long haul applications.

Jannu leapfrogs competitors' proprietary transceivers that use 7nm technology and operate at 95Gbaud. These are only capable of delivering distance limited 800G because their lower symbol rate requires higher density modulation than 16QAM.

For cost-power optimized solutions, Ribbon builds on a core design practice of leveraging pluggables. This enables upgrading line cards by either simply replacing the pluggable, or re-spinning the card with minimum design impact. Our roadmap for using 0dBM coherent pluggables features continuous improvements for reducing size and increasing capacity.

- **400G CFP2 @ 64Gbaud (In use)**. Ribbon uses multiple sources of this pluggable across our optical transport and OTN switching platforms. We had its first market deployment with a line card featuring two independent 400GZR+ line interfaces.
- **400G QSFP-DD @ 64Gbaud**. This pluggable is being used in a new high-density platform, with up to an industry-leading 19.2T line capacity in 2RU.
- **800G QSFP-DD @ 124Gbaud**. This pluggable will provide superior 800G performance to existing proprietary capacity-reach optimized transceivers, with all the size, electrical power, and cost benefits of a pluggable.
- **400G CFP2 @ 124Gbaud**. This pluggable will provide an immediate upgrade for use in long haul applications to line cards using the existing CFP2 pluggable.

Ribbon 400G-800-1200G Advantage for 0dBM Applications

Figure 4 summarizes the big picture of Ribbon's solution suite for capacity-reach and power-cost optimized optical transport solutions at 0dBm. This enables providing the best fit for any optical transport application. Rather than show absolute distances that are open to debate based on conditions like fiber type and amplification, the diagram shows the relative performance of Ribbon and competitor approaches, that at a common 0dBm launch power are governed almost entirely by baud rate.

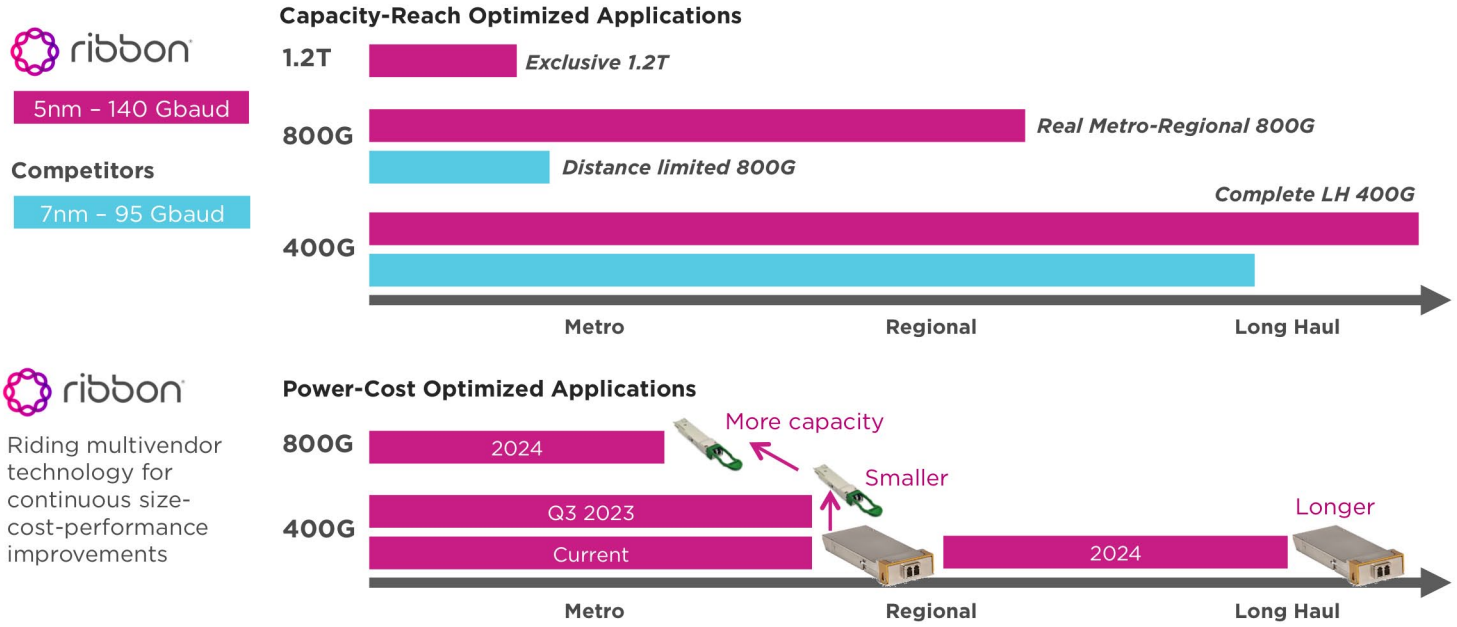

Figure 4 – Ribbon Optical Transport Performance Advantage

Notable advantages of Ribbon's approach are:

- **Far superior capacity-reach optimized solution.** Based on leapfrog 5nm-140Gbaud DSP transceiver technology, Ribbon surpasses by far current competitor approaches based on 7nm-95Gbaud technology. Specifically, our solution provides:
  - An exclusive 1.2T single wavelength solution short haul metro applications using 64QAM modulation.
  - "Real Metro-Regional 800G" able to transport across regional distances in excess of 600 miles (1000km) with 16QAM modulation, compared to current 800G solutions that barely cover small metro regions.
  - Complete long haul coverage using pure QPSK encoding.

- **Progressive power-cost optimized solutions.** Ribbon's cost-power optimized solutions, using a mix of multisource pluggable transceivers, provides continuous performance improvements that rival that of capacity-reach optimized solutions, but at a much lower cost!

- **Open Bookending.** As shown in Figure 5, this achieved for capacity-reach optimized transport based on the growing ecosystem of vendors using Acacia Jannu technology. For cost-power optimized transport, this leverages the availability of pluggable transceivers from multiple vendors implementing interoperability based on OpenROADM and other 400G+ standards.

Open Bookending Modes

Capacity-reach optimized based on common use of Acacia **Jannu** transceiver technology

Cost-power optimized based on common use of **OpenROADM** and other interoperability standards

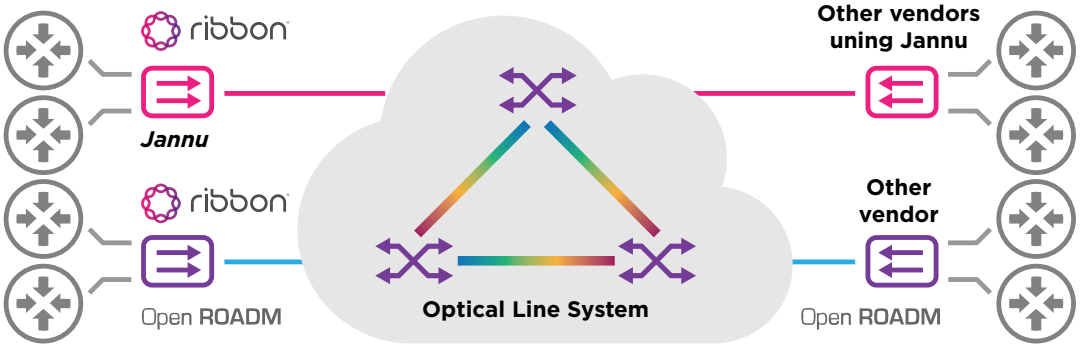

Figure 5 – Open Transponder/Muxponder Bookending

- **Orderly spectrum use**. Physics dictates that higher baud rates require wider channel widths, and Figure 6 summarizes this for all the transceiver technologies noted in this WP. Ribbon's solutions operate entirely within an orderly 75GHz/150GHz grid. This enables much more efficient spectrum use compared to competitor approaches based on a 112.5GHz channel width, which can easily lead to wasted or abandoned spectrum as the network evolves.

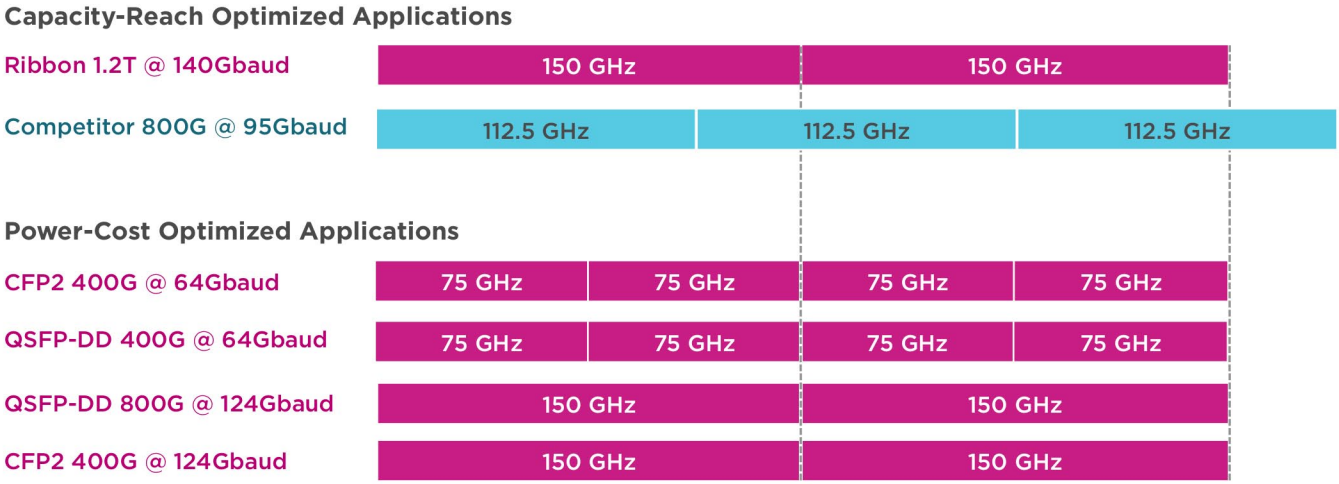

Figure 6 – Transceiver Technologies Spectrum Use Comparison

Summary – Converged "Metro plus Long Haul" Optical Transport

Ribbon's optical transport strategy has operational simplicity and drives down the overall cost per bit. Its key value are:

1. Exclusive 1.2Tshort haul using 64QAM, real 800G metro-regional using 16QAM, and unlimited 400G long haul using QPSK.
2. Co-existence of capacity-reach and cost-power optimized solutions within a rational 75GHz/150GHz spectrum structure.
3. A commitment to open bookending of transceivers for capacity-reach optimized solutions with any vendor using Jannu technology, and for cost-power optimized solutions with any vendor implementing the OpenROADM MSA and other interoperability standards.

Contact Us Find Out More About No Limits Metro-Regional 800G and Long Haul 400G Optical Transport

About Ribbon

Ribbon Communications (Nasdaq: RBBN) delivers communications software, IP and optical networking solutions to service providers, enterprises and critical infrastructure sectors globally. We engage deeply with our customers, helping them modernize their networks for improved competitive positioning and business outcomes in today's smart, always-on and data-hungry world. Our innovative, end-to-end solutions portfolio delivers unparalleled scale, performance, and agility, including core to edge software-centric solutions, cloud-native offers, leading-edge security and analytics tools, along with IP and optical networking solutions for 5G. We maintain a keen focus on our commitments to Environmental, Social and Governance (ESG) matters, offering an annual Sustainability Report to our stakeholders. To learn more about Ribbon visit rbbn.com.