Apollo 100GbE & 400GbE Transport Solutions

Performance and Cost-Power Optimized Solutions for Greenfield and Brownfield Networks

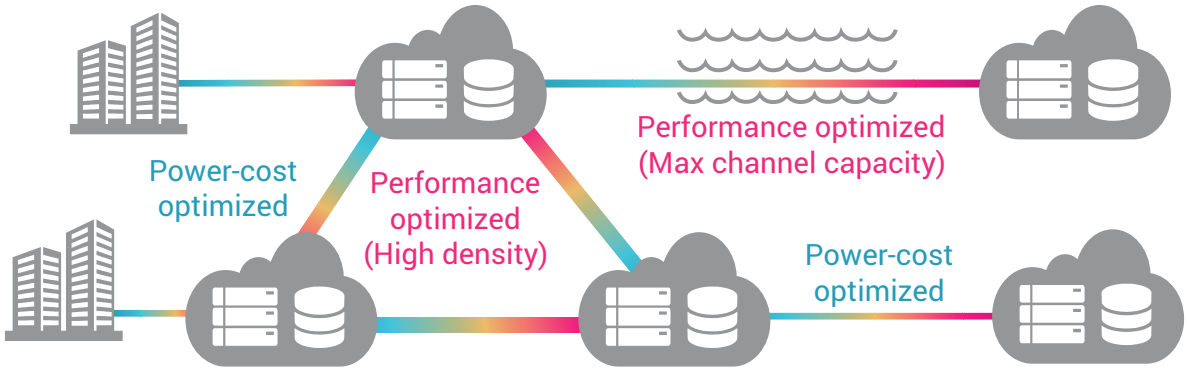
Optical networks rely on two types of solution to transport predominant 100GbE client traffic and increasingly important 400GbE client traffic.

Performance Optimized Transport

Maximizes spectral efficiency for any distance and fiber condition. Achieves low cost per bit for applications with very high traffic densities, such as high-density metro transport among data centers. It also maximizes line rates over long distances, such as transport between regions or undersea links, where there is a need to squeeze every bit of capacity from a channel.

Power and Cost Optimized Transport

Provides strong enough performance for most applications. This solution is typically used when performance optimized transport is not needed. Examples are medium or low-density metro and regional transport, such as connecting Enterprise locations to data centers, and long distance transport that does not require maximizing channel capacity.



100GbE and 400GbE Transport Solution Types

Apollo supports both solution types, with multiple advantages:

Flex and fixed grid
All solutions can operate in both greenfield flexible grid networks with no constraints on channel width, as well as in fixed grid 50GHz or 100GHz networks. Many competitive solutions cannot be deployed in fixed grid networks.

Single and dual carrier
All solutions support both single carrier and dual carrier mode. The benefit of dual carrier mode is that by combining two carriers with less dense modulation schemes, it achieves the same line rate as competitive solutions limited to a single carrier, but exceeds them by far in transport distance.

Interchangeable blades
All 100GbE and 400GbE blades are deployable interchangeably in any of Apollo's small, medium or large transport platforms, facilitating cost-effective network configurations and growth.

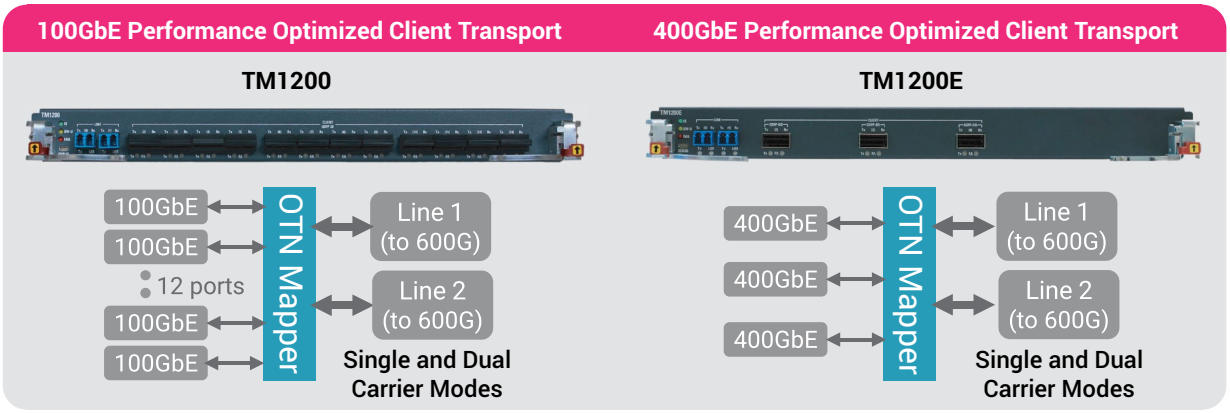
Pay as you grow
The pluggable line interfaces on the TM400_2 cost-power optimized solution enables adding line capacity incrementally as traffic grows.

Built-in monitoring
All blades have built-in monitoring that provides continuous OSNR and performance feedback.

Disaggregated deployment
The blades all support both OpenConfig and OpenROADM control interfaces so they can be deployed easily as alien wavelengths in disaggregated networks.

Apollo Performance Optimized 100GbE and 400GbE Transport

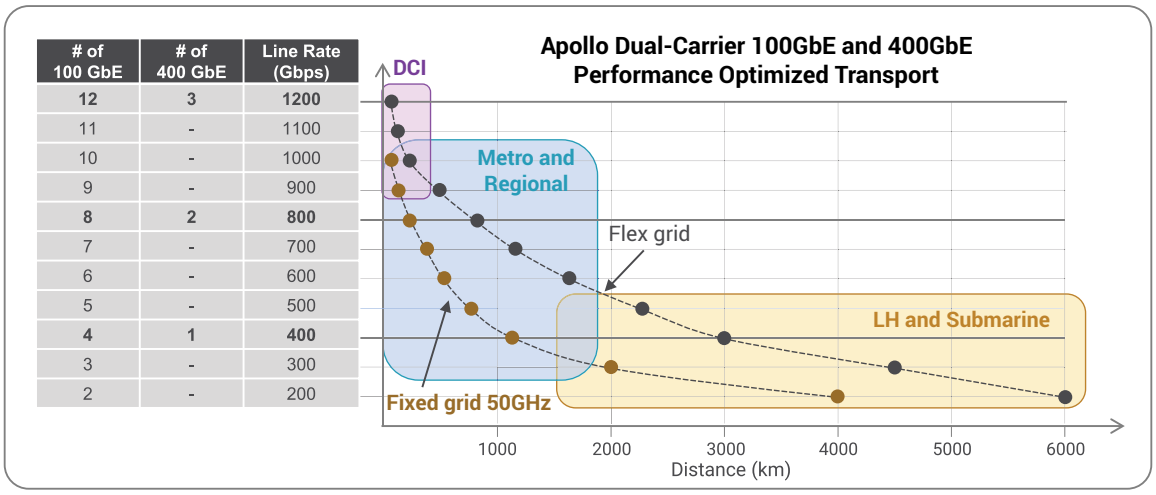
Apollo provides two sets of performance optimized 100GbE and 400GbE transport blades. The TM1200 muxponder maps up to 12 100GbE clients onto two line interfaces, while the TM1200E maps up to 3 400GbE clients onto the line interfaces. (Not shown are the TM800 and TM800E versions, that support 8 100GbE clients and 2 400GbE clients, respectively.)



Apollo performance optimized transport blades employ programmable line interfaces – based on 3D Shaping technology, which includes fractional QAM modulation and adaptive baud rates – to maximize the line rate for a given link based on distance and noise conditions.

Each blade has two line interfaces that can operate either independently or in a dual-carrier mode. In independent mode, each line interface is programmable for rates of 100G to 600G in 50G increments. As they are independent, each line interface can transmit on a common fiber or on two different fibers in different directions. In dual-carrier mode, the two line interfaces effectively combine into a single channel to achieve rates of 200G to 1200G in 100G increments. This single or dual carrier capability provides Apollo performance optimized blades with tremendous versatility.

Particularly noteworthy is the adaptive baud rate capability of these blades that enables them to operate in brownfield fixed grid 50GHz and 100GHz channel spacing networks. By down speeding the adaptive baud rate these blades can adapt to restrictive brownfield conditions.

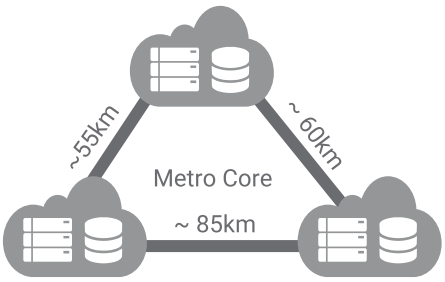


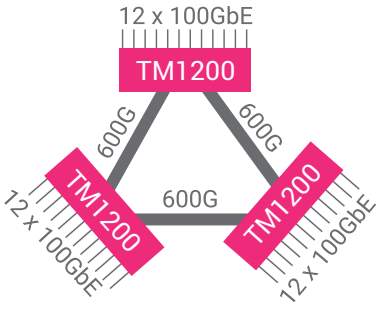
# of 100 GbE	# of 400 GbE	Line Rate (Gbps)
12	**3**	**1200**
11	-	1100
10	-	1000
9	-	900
8	**2**	**800**
7	-	700
6	-	600
5	-	500
4	**1**	**400**
3	-	300
2	-	200

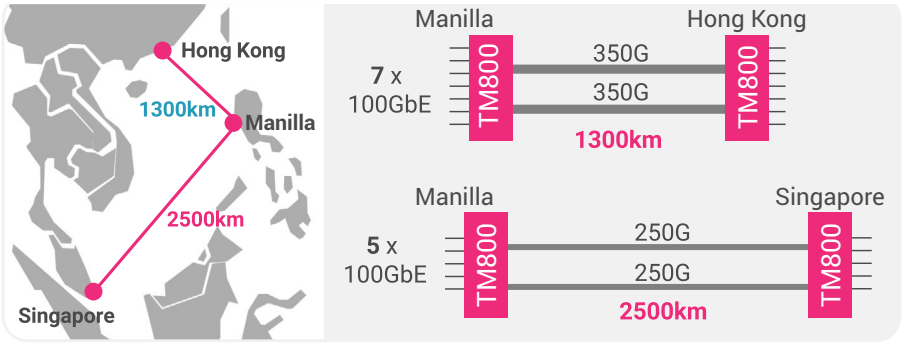
Apollo Performance Optimized 100GbE and 400GbE Transport – Dual Carrier Mode

Application Example – High Traffic Density Metro Core

The customer needed to interconnect three data centers within a metro core. The TM1200 enabled full mesh connectivity with just three blades, supporting 6 x 100GbE links between each data center.







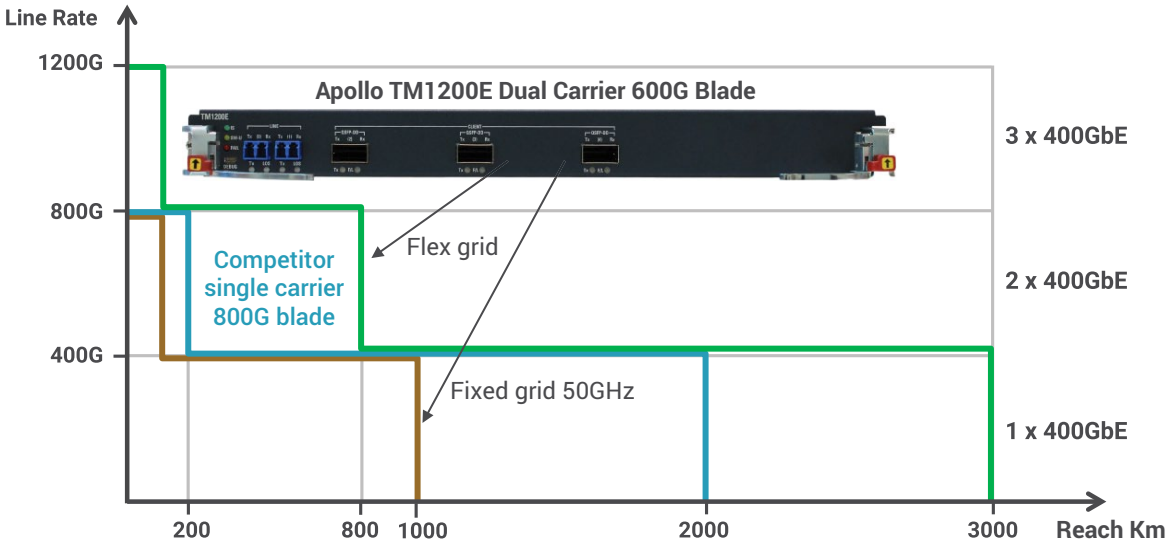
Application Example – Undersea Links

The customer needed to maximize the number of 100GbE clients on two submarine links. By using the TM800 in dual carrier mode, with 50G increments on each carrier, Apollo was able to extract 25% more capacity that the leading competitor's approach.

Competitive Advantage of Dual Carrier Performance

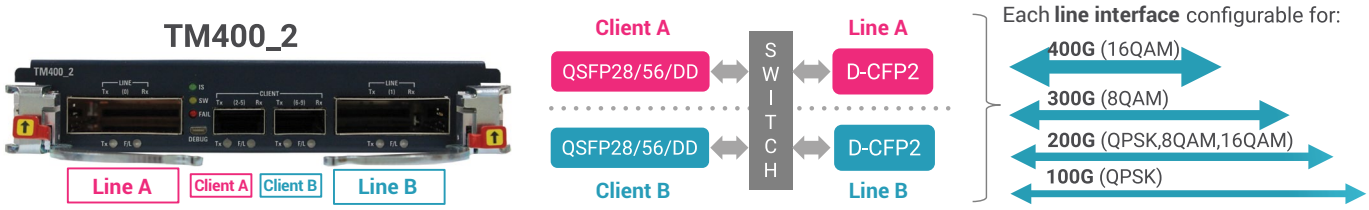
The diagram below, focusing on 400GbE transport, illustrates how Apollo's dual carrier capability delivers superior performance to competitive solutions that are restricted to a single carrier. Specifically,

- For DCI applications, Apollo exclusively transports three 400GbE clients.
- For metro and regional applications, Apollo transports two 400GbE clients for about 800km, versus the competitor's very limited 200km.
- For long haul transport of a single 400GbE client, Apollo exceeds 3000km while the competitor is limited to 2000km.
- Apollo is able to transport 400GbE clients in brownfield fixed grid applications, which the competitor cannot do at all.



Power and Cost Optimized 100GbE and 400GbE Transport

The Apollo TM400_2 dual transponder-muxponder combines software-programmable modulation with an internal switch to provide the industry's most compact, low power, and versatile transport of 100GbE and 400GbE clients for metro, regional, and long haul applications. It is ultra-compact and ultra-low power featuring < 0.18W/Gbps with all plug-ins at 2 x 400G. The TM400_2 rides the price-performance curve for 400G CFP2 DCO pluggables and is configurable with several versions of these pluggables. This includes proprietary modulations and SD-FEC for maximum long haul reach, as well as using standard OpenROADM oFEC that can interwork with other 400G ZR+ line cards to support disaggregated networks.



Client Type	Client A	Client B	Line A	Line B	Application
100GbE	4 x 100GbE*	4 x 100GbE*	400GbE	400GbE	DCI-Metro
	2 x 100GbE	2 x 100GbE	400GbE	–	DCI-Metro
	2 x 100GbE	100GbE	300GbE	–	Metro
	2 x 100GbE	2 x 100GbE	200GbE	200GbE	Metro-LH
	2 x 100GbE	100GbE	200GbE	100GbE	Metro-LH/ULH
*fan-out	100GbE	100GbE	100GbE	100GbE	ULH-Submarine
400GbE	400GbE	400GbE	400GbE	400GbE	DCI-Metro
	400GbE	–	200GbE	200GbE	LH

Pay as you Grow

A big advantage of the TM400_2 is its ability to add line capacity incrementally as traffic grows. On day one it can support up to 400G capacity using a single CFP2 DCO pluggable, and then when there is demand for more client transport it can add another pluggable.

Open Standard Interfaces for Disaggregated Solutions

Begin benefiting from Apollo's outstanding 100GbE and 400GbE transport capabilities today, even if you do not have an Apollo network. All Apollo transport platforms support OpenConfig or OpenROADM northbound control interfaces to facilitate their deployment and control as alien wavelengths in existing networks.

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.

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