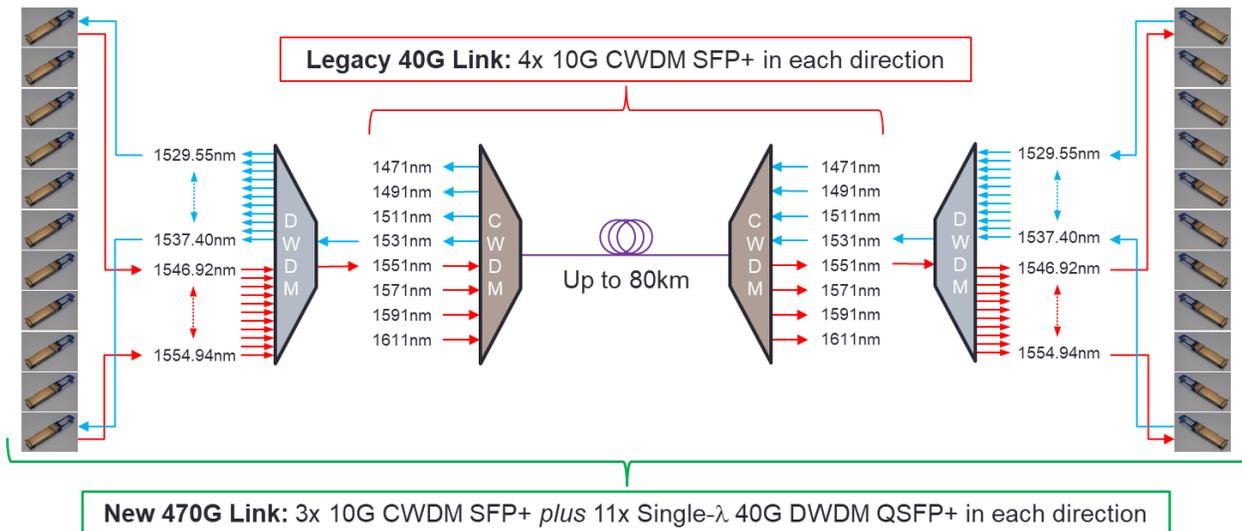


## A Cost-Effective Approach to Increase Network Capacity

As demand for data center bandwidth continues to skyrocket traditional 10G NRZ SFP+ optical modules, although inexpensive, can't keep up putting pressure on data center operators to get more out of their networks. A great option is PAM4-based Single- $\lambda$  40G QSFP+ transceivers. They are compatible with existing QSFP+ switch ports, but they provide four times the data over a single-mode fiber, better utilizing that fiber.

Electrically, 40G PAM4 transceivers function just like standard 40G NRZ transceivers with a 4x10G interface, but the optical output is a single- $\lambda$  at 40 Gbps. Their design utilizes a 20 Gbaud per second laser and a PAM4 gearbox to generate two bits per symbol resulting in a 40 Gbps optical signal. By replacing 10G NRZ modules with 40G PAM4 modules a 40-channel DWDM data link will provide 1.6 Tbps, an impressive 4x improvement with minimal investment. A comparable 1.6T link based on 100G Coherent optics is about 2.5x higher cost and about twice the power consumption.

10G-based CWDM links can reap even greater benefit. Consider the case of a legacy 40G BiDi link having 4x 10G CWDM SFP+ modules operating in each direction as shown in the figure below. By replacing the 1531nm and 1551nm 10G CWDM modules with a DWDM mux/demux up to 11x 40G PAM4 DWDM transceivers can be added in each direction to achieve 470 Gbps, a massive capacity increase of nearly 12x without needing more fiber.



While the benefits are clear, a couple of additional factors must be considered when moving from 10G to 40G optical transmission. First, since dispersion increases with frequency a DCM may be required if the DWDM link distance exceeds 10km. Second, receiver sensitivity degrades with increasing frequency, and a link loss of more than 10dB may require an EDFA. However, the cost of each of these components is very reasonable and adds very little to the overall cost of the upgrade.

For more information about 40G PAM4 DWDM QSFP+ transceivers, please contact:

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