Solutions

40Gbps and 100Gbps Services on Metro Networks

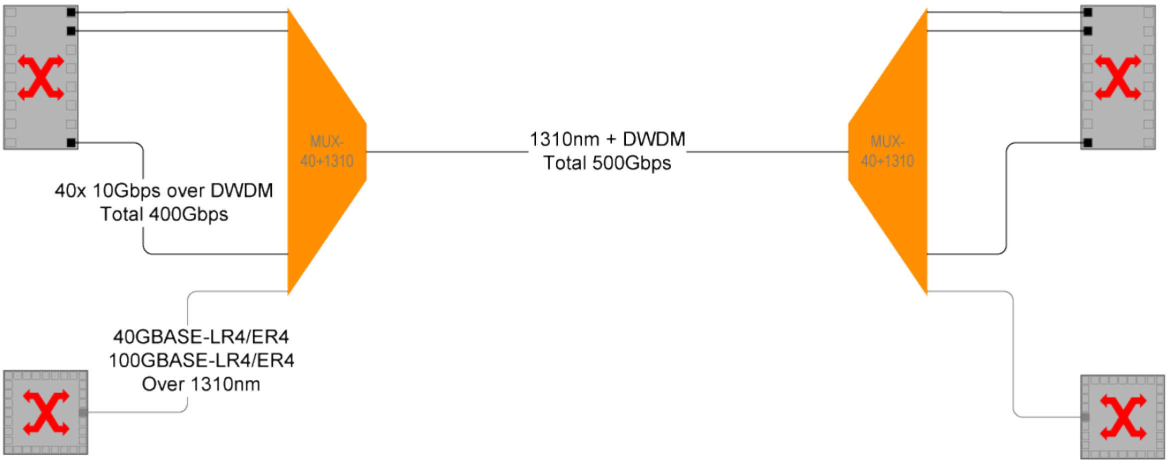
1 Introduction

Long-haul 40Gbps and 100Gbps ITU / OTN transponders, based on active chassis-based and vendor proprietary systems are on the market since some time now. As those are targeted for the very challenging transport over hundreds if not thousands of kilometers solutions, all solutions are relying on complex technologies involving differing modulation formats such as DPSK (Differential Phase Shift Keying), DQPSK (Differential Quadrature PSK), DP-QPSK (Dual Polarization-QPSK) etc. Since this complexity does not come for free, the IEEE bodies have standardized pluggable 40Gbps and 100Gbps transceivers for "shorter reaches", and while limiting the requirements have reduced the associated cost tremendously. Although the majority of those transceivers covers very short distances (e.g. 10m, 100m) the 40GBase-LR4 and 100GBase-LR4 versions are capable for metro network applications and associated distances of up to 60km.

2 Overlaying 10Gbps networks with additional 40Gbps or 100Gbps services

In a typical scenario a metro network already exists, often relying on multiple 1Gbps or 10Gbps services which are multiplexed over the dark fiber network. The goal therefore, is not to take down the network and replace it by a new infrastructure but to add the new services without effecting the legacy installation, at lowest possible CAPEX and OPEX while still being simple to install and maintain.

This can easily be achieved by adding the 40Gbps / 100Gbps service via a passive transport approach. In this scenario the according 40GBase-LR4 / 100GBase-LR4 (or future -ER4) transceiver (as e.g. CFP, QSFP, CFP2 etc MSA format) will be directly plugged into the terminal equipment, into the Ethernet switch, router etc. The new service can then be overlaid on the existing DWDM (or CWDM) network by adding it through a 1310nm band pass port on the (maybe existing) DWDM (or CWDM) passive multiplexer:

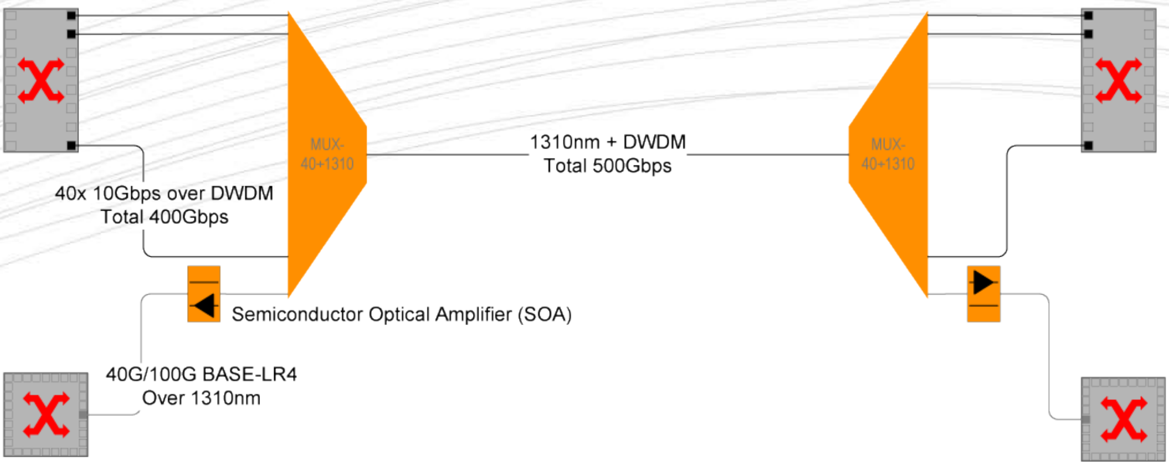


If this 1310nm band port is integrated into a 40 channel 100GHz DWDM passive multiplexer, then this set-up allows the transport of up to 40 services at 10Gbps plus 100Gbps over 1 fiber pair, in total 500Gbps, implemented into 1HU/19" rack space without consuming any electric power.

3 Overcoming reach limitations

Although the IEEE bodies have standardized LR4 and ER4 versions for 10km and 40km reach, which are both operating in the 1310nm optical spectrum, the availability of the later ER4 (40km) versions is "limited". In practice this means ER4 transceivers are commercially not available and it is questionable if or when that might change. This effectively limits the use of metro applicable 40GBase and 100GBase to the LR4 versions. Those are nominally addressing distances of "up to 10km" - which are achieved for a perfect single mode fiber, without losses of splices, patch cords, ODFs or other reasons. Moreover the additional multiplexer will insert extra losses, hence the effective reach of such a LR4 transceiver will decrease to 6km or maybe even only 4km. This would then limit the use very drastically to some rare cases.

However, that obstacle may be solved by introducing a stand-alone but managed (SNMP etc) SOA (Semiconductor Optical Amplifier): since the LR4 optics operate in the 1310nm range the usual metro transport EDFA (Erbium Doped Fiber Amplifiers) supporting the 1550nm spectrum would not only not amplify but even block the LR4 signal. In contrast to EDFAs the SOAs are amplifying the 1310nm spectrum but vice versa are blocking all 1550nm signals. Accordingly the additional SOAs must be implemented between the 1310nm multiplexer port and the LR4 transceiver.



As with any amplified transmission here as well the signal quality and signal to noise ratio is of high importance. The SOAs therefore, have to be used as pre-amps (and not boosters) to amplify the incoming (Rx) signal on the receiving side of the link. Preferably and to extend reaches to the absolute maximum LR4 transceivers should be selected that exceed their specification in terms of signal quality. Doing so enables distances of up to 60km reach.

Passive WDM transport means can be used to set-up multiple, up to 24, 100Gbps services in the same way that passive DWDM 10Gbps networks have been used to augment capacity in metro environments. And similar to passive 10G WDM networks, passive 100G DWDM networks are installed at a fraction of the cost of the active transport counterparts.

Similar to the LR4 versions featuring 4 lasers and 4 detectors (each at 25Gbp, each at specific lambdas), the heart of passive 100Gbps DWDM solutions are 100Gbps DWDM CFP MSA compliant transceivers - they only come without the optical WDM multiplexer integrated into the transceiver. This requires an external (e.g. 19" based, passive DWDM) multiplexer.

In contrast to CFP LR4 types, the CFP DWDM versions are based on tunable lasers (50GHz DWDM grid) in the 1550nm spectrum.
A set of up to 24 "differently colored" 100Gbps DWDM can be transported via a 96 channel passive DWDM mux (each CFP uses 4 lambdas) in parallel over a single-mode fiber pair.

Similar to 10Gbps DWDM networks, those signals can be reach-extended by the use of standard EDFA (Erbium Doped Fiber Amplifier) amplifiers. This enables the transport of up to 2.4 Tbps in a passive WDM manner without additional and costly amplifiers over distances of hundred and more km's.

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