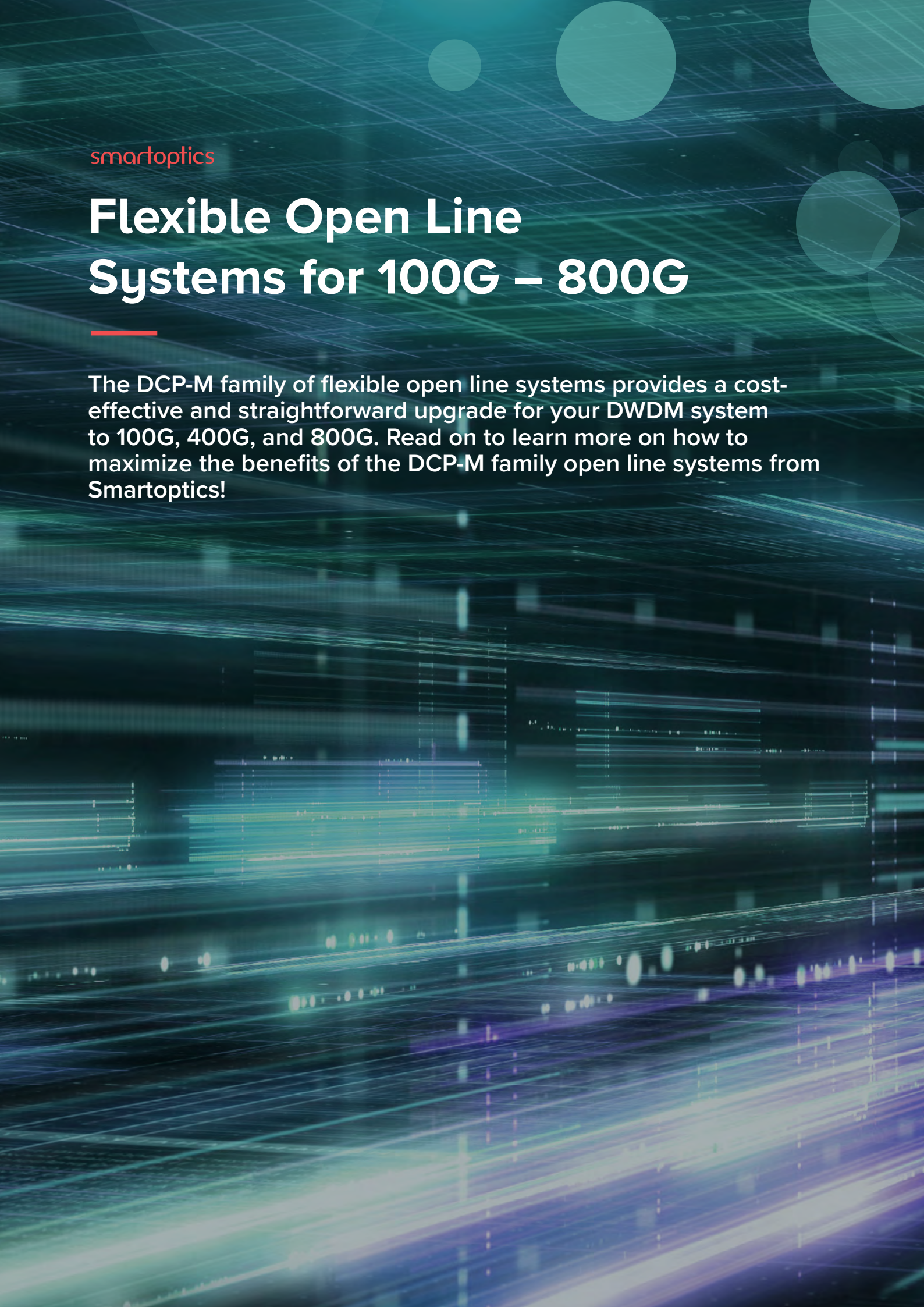
smartoptics

# Flexible Open Line Systems for 100G – 800G

The DCP-M family of flexible open line systems provides a cost-effective and straightforward upgrade for your DWDM system to 100G, 400G, and 800G. Read on to learn more on how to maximize the benefits of the DCP-M family open line systems from Smartoptics!



# The World of Open Optical Networking

Today's optical networks employ pluggable DWDM transceivers, which are inserted directly into the switches and routers within the data network and linked together using an open line system. By utilizing open line systems and Software Defined Networking (SDN) control, such networks achieve scalability and optimal performance at the lowest possible cost. Smartoptics has always been a pioneer when it comes to disaggregated "IP over DWDM" architectures, providing optimized solutions for easy to use, cost-effective, and high capacity open optical networks.

An open optical network is also ideally suited to carry wavelengths from multiple sources over the same infrastructure. With a separate open line system carrying the DWDM wavelengths over longer distances, there is no penalty or licensing fee for transporting "alien wavelengths" alongside the wavelengths emanating from your own transceivers.

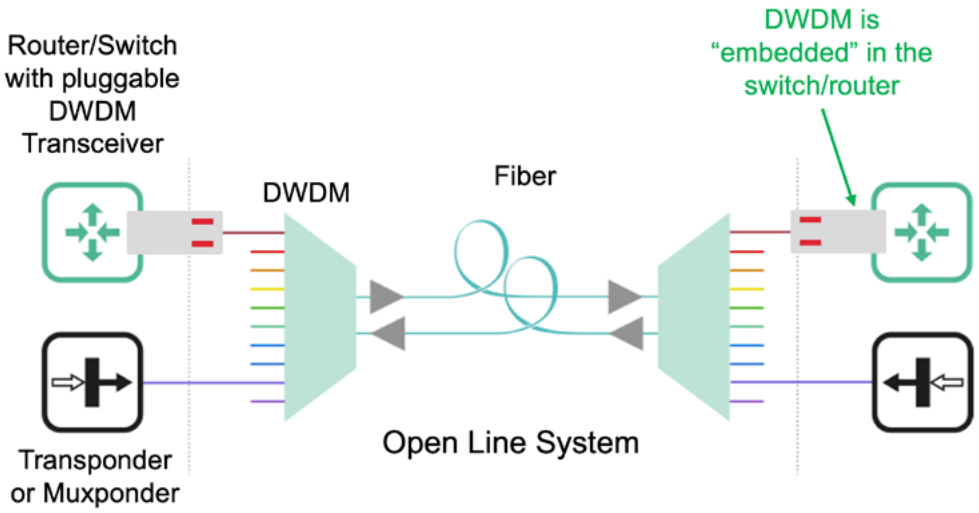



Figure 1. The IP over DWDM architecture

The Smartoptics products are designed for a maximum level of automation and "plug-and-play", while at the same time enabling advanced functions, such as encryption at the optical layer. And to simplify the integration in the data center or metro network, they all adhere to the standard rack mount building practice and have standard management interfaces.

# Data Center Interconnect and Metro Networks

The DCP-M family of active open line systems comprises a set of 1RU units for all types of point-to-point applications where DWDM is used to carry multiple services between two geographically separate sites. This is typically the case when an enterprise has more than one data center, for example for redundancy, and wants a fast and reliable link between the two sites. Or you may be a dedicated provider of cloud services, running data centers at multiple sites, requiring high-capacity connectivity between your locations. In both scenarios, the distances usually do not exceed 80 km, and the transport services are primarily Ethernet; occasionally, Fibre Channel is also used by a Storage Area Network.

If your switches/routers already support the relevant DWDM transceivers (data rate, protocol, and form factor), the embedded solution, having the transceivers directly connected to the ports of the DCP-M line system, has the lowest cost and least latency. And if no suitable DWDM transceivers are available, a transponder or muxponder can be used to convert the output of the router/switch to the DWDM format.

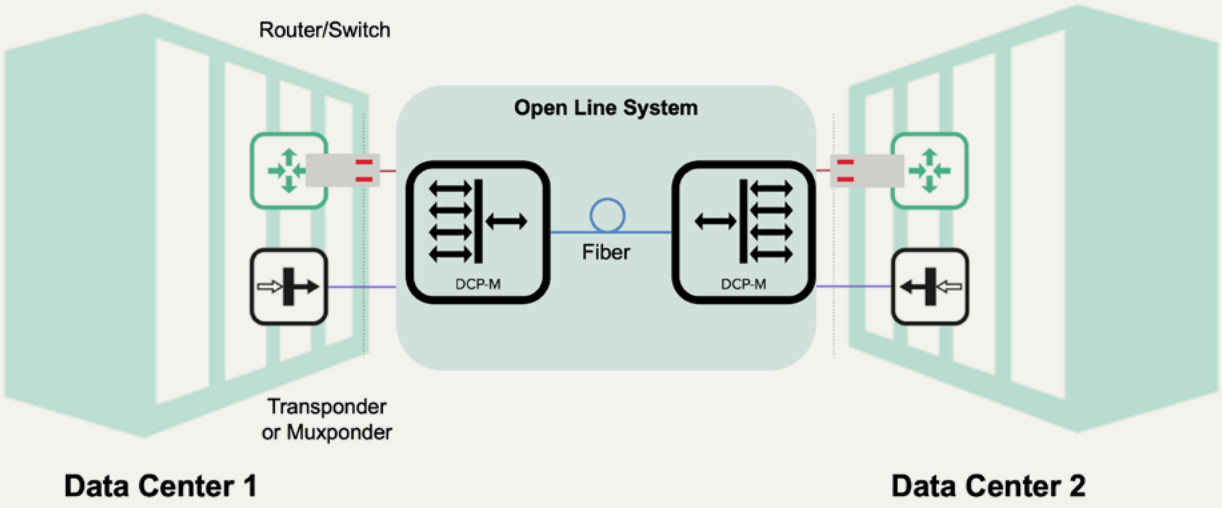



Figure 2. Data Center Interconnect

Data center interconnect is possible without an active open line system, for example using passive DWDM multiplexers, but only for short distances and with limited capacity. An active optical line system like the DCP-M family supports higher data rates over much longer distances and in addition gives you much better monitoring and fault detection capabilities.

The fundamental cost advantage of higher data rates lies in the fact that you can multiplex several lower speed connections over the same optical channel. For example, ten 10G Ethernet connections can be multiplexed over one 100G channel and eight 100G connections can be multiplexed over one single 800G channel. In addition, the higher data rates also decrease the time it takes to transmit a data packet over the connection. And given that your switches support 400G or 800G interfaces, you may now directly leverage the full capacity between your sites and towards your customers.

The use of direct point-to-point links is not restricted to data center interconnect scenarios only.

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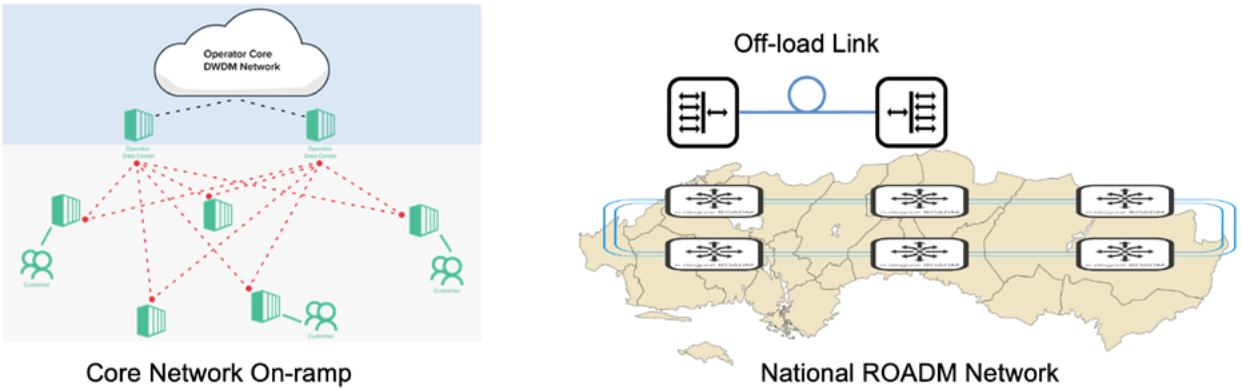


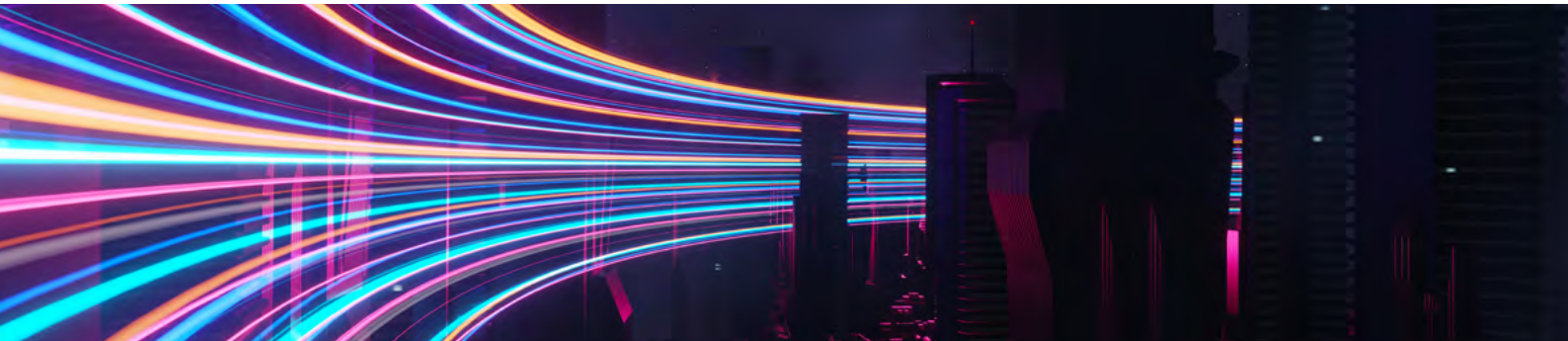

Figure 3. Point-to-point links in operator networks

In the metro area, service providers and operators typically serve the traffic from different data centers. These are spread out over a metropolitan area and interconnected by high-speed fiber optical links. While some data centers are seen as “main sites” and given nation-wide connectivity via the operator’s core DWDM network, other data centers primarily serve as connection points for enterprises, content providers, and for capacity wholesale.

To increase the capacity in the metro area and to provide their customers with high-speed 100G, 400G, and 800G links, service providers are increasingly implementing separate metro networks in order not to overload their core DWDM network.

In many cases these metro networks can most easily be implemented by a set of point-to-point connections, accomplished by the DCP-M family open line system.

Another common scenario is an operator deploying a nationwide ROADM-based DWDM network. However, most of his customers are found in the metropolitan areas and will only use one or two hops in the ROADM-network. This leads to poor wavelength utilization in other parts of the ROADM ring, and hence an attractive solution is to serve these customers with direct, IP over DWDM, links based on the DCP-M family between adjacent nodes.



# Active/Passive Access Networks

Often, an operator needs to backhaul traffic from multiple sites that are spread across different locations to a central point, such as when building the backhaul infrastructure for a mobile network. Having to place an active DWDM multiplexer at each site may easily become a significant cost. Smartoptics has therefore developed an innovative solution with combined active and passive nodes. The solution typically uses one DCP-M40-DE unit in the hub node and passive DWDM filters in the satellite nodes. With two DCP-M40-DE, it is possible to build a 10G, 100G, or 400G ring or arch with redundant traffic from each passive node to the hub.

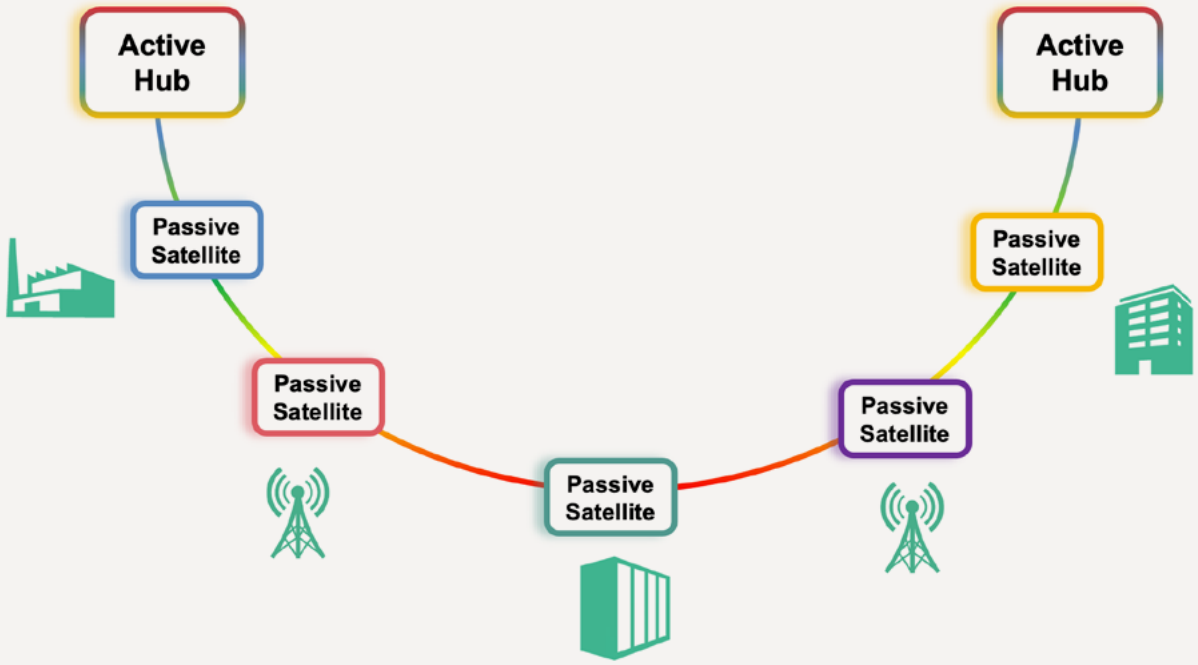



Figure 4. An active/passive access network arch with DCP-M40-DE

One DCP-M40-DE unit includes all optics needed for one direction in the hub node. This means that amplifiers, OCM, WSS, and filters are included in the 1RU chassis. The dual WSS component allows for automatic power balancing for both outgoing and incoming signals, so that no individual attenuators are needed in the passive nodes. Having all components inside one 1RU chassis reduces size, power and complexity. The fiber management is limited to external connections since all internal connections are inside the chassis.

# Meet the DCP-M Family

The DCP-M family comprises a set of 1RU active open line systems for use in combination with embedded optics in point-to-point applications between sites at distances up to 140 km (80 km for PAM4). Depending on DCP-M model, 40 or 32 channels with the following protocols and modulations are supported:

- 40G/100G PAM4 DWDM
- 1G-64G NRZ modulated signals
- 100G-800G coherent DWDM signals

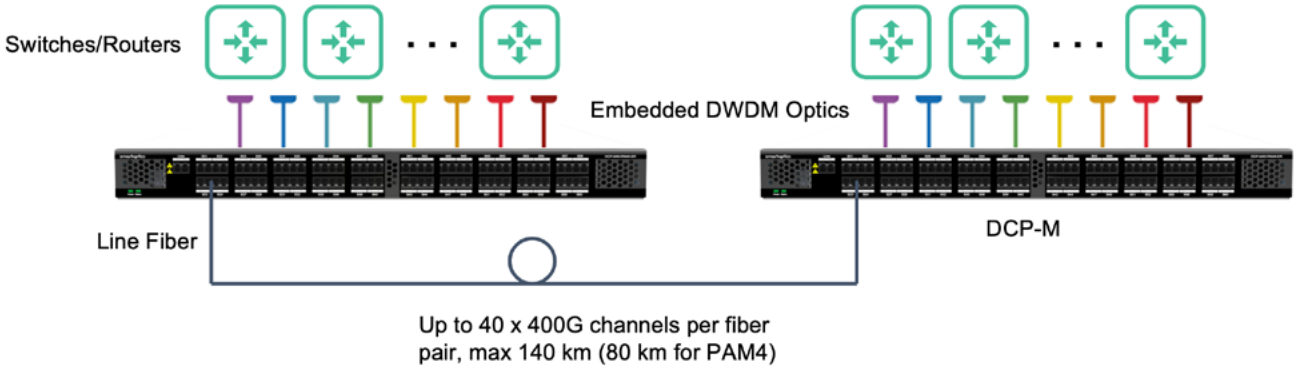



Figure 5. The DCP-M use case

The rationale behind the DCP-M family has always been to extend the reach of embedded optics and to remove the dependency on complex telecom grade optical systems. DCP-M is an intelligent, distance-bridging, multiplexer with open management protocols, a DWDM multiplexer capable of transporting traffic from any combination of pluggable transceivers, transponders, and muxponders.

## The Need for an Active Open Line System

You may wonder why you need an active line system in your DWDM network. The answer lies in the steadily growing capacity of your new routers and switches and the increased capability of the pluggable DWDM transceivers that you now can use. As stated above, higher line rates allow for more traffic on the same fiber, which in turn reduces the cost per transported bit and enables increased income. But the higher line rates also put more stringent requirements on the line system, for example when it comes to signal/noise characteristics and dispersion tolerance.

The active line system is the prerequisite for leveraging the new high-speed formats specified by standards from e.g. the Optical Internetworking Forum (OIF) and the Open ROADM Forum. In addition, the active line system also monitors the traffic and can amplify the signals for longer distances.

## Very High Density

The DCP-M family has been designed with the data center in mind. It has the same form factor and cooling as any standard switch, which means that it fits seamlessly into your existing racks, giving you 40 DWDM channels in only 1 RU. High throughput, up to 25.6 Tbit/s per fiber pair, combined with minimal power requirements and the lowest possible space requirements at an attractive price means a rapid return on your investment. And DCP-M can even be used in single fiber configurations, should availability of fiber pairs be scarce.

## Plug-and Play

DCP-M brings an unprecedented level of plug-and-play simplicity to DWDM networking, being designed with ease of use in focus. DCP-M comes with a completely automated optical setup. Power levels are automatically regulated on both sides of the connection when a channel is activated, and a LED confirms visually that the channel is set up correctly. Consequently, a minimum level of optical networking knowledge is required to start up a DCP-M link, it is just like using a passive multiplexer.

DCP-M measures the fiber length once an end-to-end connection is in place, and this allows for an automatic setting of the tunable dispersion compensation. Pre-configuration of parameters like node name and IP-address, if applicable, mean that this is a system that is installed with zero touch.

## Modern Management Architecture

A Command Line Interface (CLI) is used to provision additional configuration data to the DCP-M, and if you are familiar with the CLI commands for a switch or router, then you can easily configure the DCP-M. Configuration is minimal and straight forward and additional gNMI, SNMP, and REST interfaces expand the functionality. Standard and configurable REST commands are available for easy integration with other network telemetry and management systems via APIs. A combination of industry standard and configurable SNMP alarms provides all the necessary web-based monitoring functions for the DCP-M. New services, elements, or sites are seamlessly added with no impact on the network performance.

## Automated Control Loops

To simplify the overall monitoring of the DWDM link between sites, DCP-M comes with automated control loops, both on the client (switch/router) side and on the optical line side.

The client control loop performs automatic protocol detection, automatic power level measurement, and automatic power level regulation. The line control loop performs automatic measure of fiber length, automatic setting of dispersion compensation, and automatic power level regulation. It is thanks to these automated functions, the installation of DCP-M becomes so simple.

## Optical Time Domain Reflectometer (OTDR) SFP Support

All DCP-M family units have an Optical Supervisory Channel (OSC) port for different reach and for external Optical Time Domain Reflectometer use in the 1625 nm band.

An OTDR SFP injects a series of optical pulses into the fiber under test and extracts, from the same end of the fiber, light that is scattered or reflected from points along the fiber, such as optical distribution frames (ODFs), bad splices, or fiber cuts. The return pulses are measured as a function of time and can then be used to create a table of distances to the reflection points.

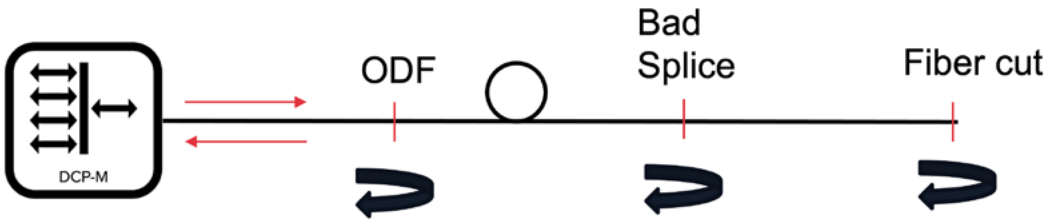



Figure 6. Optical Time Domain Reflectometer (OTDR)

The special pluggable OTDR transceivers from Smartoptics are a combined Optical Supervisory Channel (OSC) and OTDR SFP operating in one of 2 wavelengths (1491 or 1511 nm) and capable of measuring reflection points at a distance up to 100 km with an accuracy of 50 m or better.

## Distances and Data Rates

Leveraging the flexibility of open optical networking, Smartoptics was able to introduce coherent 400G DWDM based on the 400ZR standards earlier than most other players on the market. Once again, the advantage of disaggregated optical networking, where transceivers and line systems can make immediate use of advances in their respective technologies, has enabled Smartoptics to develop solutions having superior performance without excessive costs.

800G coherent line specifications for campus and DCI applications use the same modulation format as 400G, but with higher baud rates. The higher baud rates (~120GHz) in combination with QPSK modulation can also be used to enable a better optical signal/noise tolerance, a fact that can be leveraged to create ultra long-haul 400G optical links.

The higher baud rates require an even wider channel passband than 400G connections in the optical line system. This fact has been taken into consideration when designing the DCP-M32-CSO-ZR+, which is already “800G-capable”. So, when using 800G pluggable transceivers, you can stay with your already deployed optical line system. Once again, a clear cost benefit of the disaggregated “IP over DWDM” approach taken by Smartoptics.

The DCP-M32-CSO-ZR+ also supports the use of in-line optical amplifiers, further extending the reach of the open line system. Using such amplifiers up to 10 individual spans covering a total distance of 1000+ km can be covered, if your DWDM channels are running at 400G.

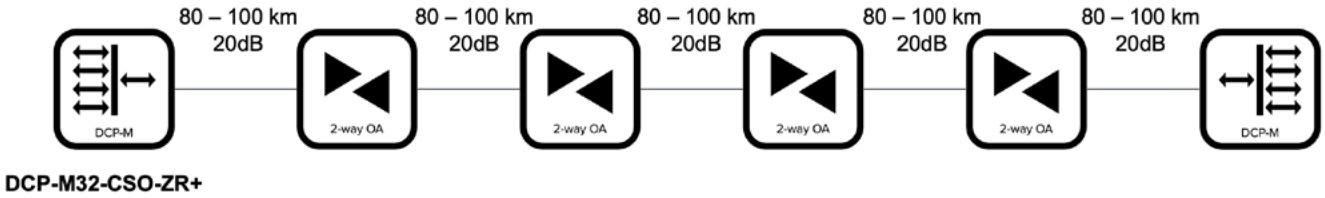



Figure 7. In-line optical amplifiers can be used to extend the reach of DCP-M32-CSO-ZR+

## Configuration Examples

If you opt for a 100G solution with PAM4 transceivers in the QSFP28 form factor, an active open line system such as Smartoptics DCP-M40-MSO-ZR will be required to handle the low optical power and the dispersion properties of the optical signal. The DCP-M40-MSO-ZR supports up to 40 individual PAM4 DWDM channels if you have access to a fiber pair between the sites and up to 20 full duplex channels when using a single fiber. In both cases distances of up to 80 km can be bridged.

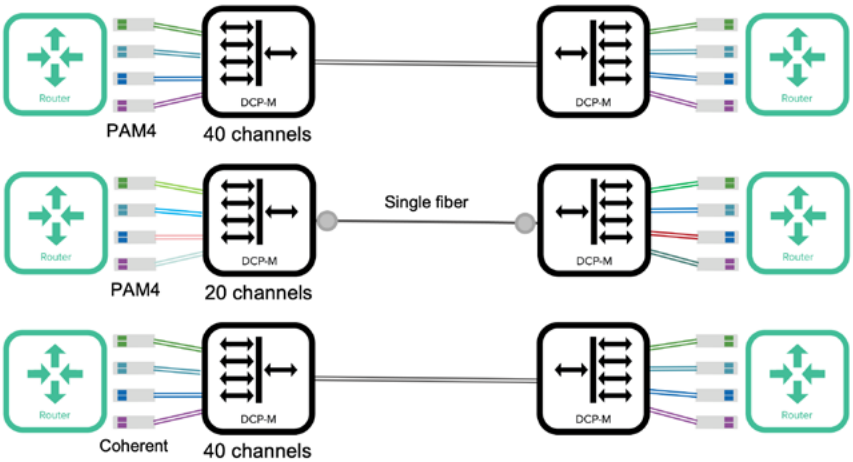



Figure 8. 100G with PAM4 DWDM using an active open line system (DCP-M40) and (bottom) 100G with coherent DWDM

Alternatively, you can go for a solution with coherent 100G capable transceivers and use the DCP-M40 line systems to handle up to 40 DWDM channels over a fiber pair. Since you are now using an active line system, a fiber loss of up to 29dB can be tolerated between the sites[1]. And if you choose to use the DCP-M40-MSO-ZR line system you may even mix pluggable PAM4 and coherent transceivers on the same DWDM connection.

400ZR transceivers implemented in the QSFP-DD form factor make it easy to upgrade to 400G by just switching transceivers. But it is even easier with the flexible DWDM-based open networking from Smartoptics. The Smartoptics solution combines the benefits of pluggable 400ZR and PAM4 transceivers with the flexible DCP-M open line systems. This enables highly automated, low-cost 100G PAM4 and 100G coherent networking while at the same time supporting 400ZR, so that existing 100G channels will not be impacted at all while adding 400G channels alongside them. This way, you do not have to replace your existing optical infrastructure.

> *The Smartoptics solution combines the benefits of pluggable 400ZR and PAM4 transceivers with the flexible DCP-M open line systems.*

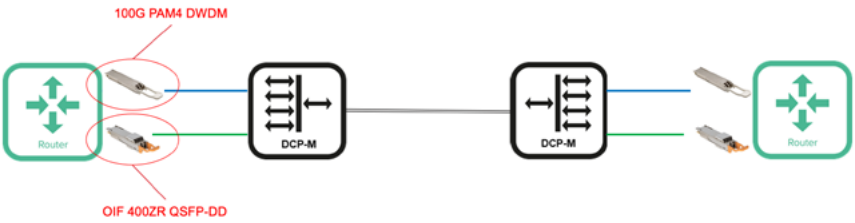



Figure 9. The DCP-M40-MSO-ZR flexible open line systems allow mixed use of 100G PAM4 DWDM and coherent 400G DWDM transceivers.

Since the 400ZR standard has less stringent optical signal requirements than 100G PAM4 DWDM, it is always possible to run a 400ZR based coherent 400G DWDM link over the same DCP-M40 flexible open line system that you have already been using for 100G PAM4 DWDM. And even better, the two modulation formats can co-exist on the same flexible open DCP-M line system without interference or distance penalties.

To further leverage the optical characteristics of 400ZR Smartoptics has also introduced the DCP-M40-CSO-ZR+ and the DCP-M32-CSO-ZR+ open line systems optimized specifically for coherent 400G and 800G DWDM.

Figure 10. The DCP-M40-CSO-ZR+ flexible open line system optimized for 400ZR

[1] Coherent signals are not limited by dispersion; hence it is only the fiber loss that determines the distance that can be bridged.

The DCPM40-CSO-ZR+ 40 channel, 16 Tbit, open line system has been designed for situations where you explicitly want to leverage the longer reach possible with coherent 100G, 200G, and 400G DWDM compared to 100G PAM4 DWDM. In addition to the coherent modulation, the DCP-M40-CSO-ZR+ also supports NRZ modulated formats, although with less optical reach.

The DCP-M32-CSO-ZR+ is designed with 150 GHz channel spacing, making it the perfect choice for supporting data rates up to 800G in modern optical networks. Built to handle the most demanding data requirements, the DCP-M32-CSO-ZR+ offers seamless compatibility with coherent DWDM signals ranging from 100G to 800G, including QPSK, 8QAM, and 16QAM formats. With its versatile architecture, this platform provides up to 160 km of reach, depending on the modulation format, ensuring reliable long-distance connectivity.

Engineered for simplicity and efficiency, both the DCP-M40-CSO-ZR+ and the DCP-M32-CSO-ZR+ feature automated configuration and zero-touch provisioning, delivering the ease of use of a passive multiplexer while integrating the advanced functionality of a modern DWDM system. Its pluggable OSC port and OTDR filter for network diagnostics further enhance its adaptability and performance in various scenarios. Both line systems are built with a compact 1U form factor unit, simplifying rack mounting.

## The DCP-M Family at a Glance

The following table summarizes some of the key characteristics of the DCP-M family. For full details and the most recent information about the DCP-M family, visit the Smartoptics web at Flexible Open Line Systems | Smartoptics.

| DCP-M Model | | Supported formats and data rates | | | | |
|---|---|---|---|---|---|---|
| | Application | NRZ[1] | 40G/100G PAM4 | 100G Coherent | 400G | 800G |
| DCP-M40-MSO-ZR | Point-to-point | Yes | Yes | Yes | Yes | No |
| DCP-M40-CSO-ZR+ | Point-to-point | Yes | No | Yes | Yes | No |
| DCP-M32-CSO-ZR+ | Point-to-point | No | No | Yes | Yes | Yes |
| DCP-M40-DE-1X40 | Active/Passive Backhaul | Yes | No | Yes | Yes | No |
| DCP-M40-DE-5X8 | Active/Passive Backhaul | Yes | No | Yes | Yes | No |

1) NRZ data rates are dependent on DCP-M model

Figure 11. The DCP-M Family

# Managing Your Network with the SoSmart Software Suite

The disaggregation of the optical network requires a similarly open approach to the management of the network elements in your 100G, 400G, or 800G network. Smartoptics has therefore developed the SoSmart Software Suite, an SDN-based tool for optical network visualization, configuration, and management of Smartoptics' products in an open, multi-layer and multi-vendor optical network environment. The SoSmart Software Suite includes a Manager with an advanced GUI for point-and-click provisioning of services, a separate Planning tool and a Controller for the interaction with the network elements. Thanks to its standardized north-bound interfaces and modular structure, the SoSmart Software Suite can easily be integrated with already deployed orchestrators and other management solutions for your transport network.

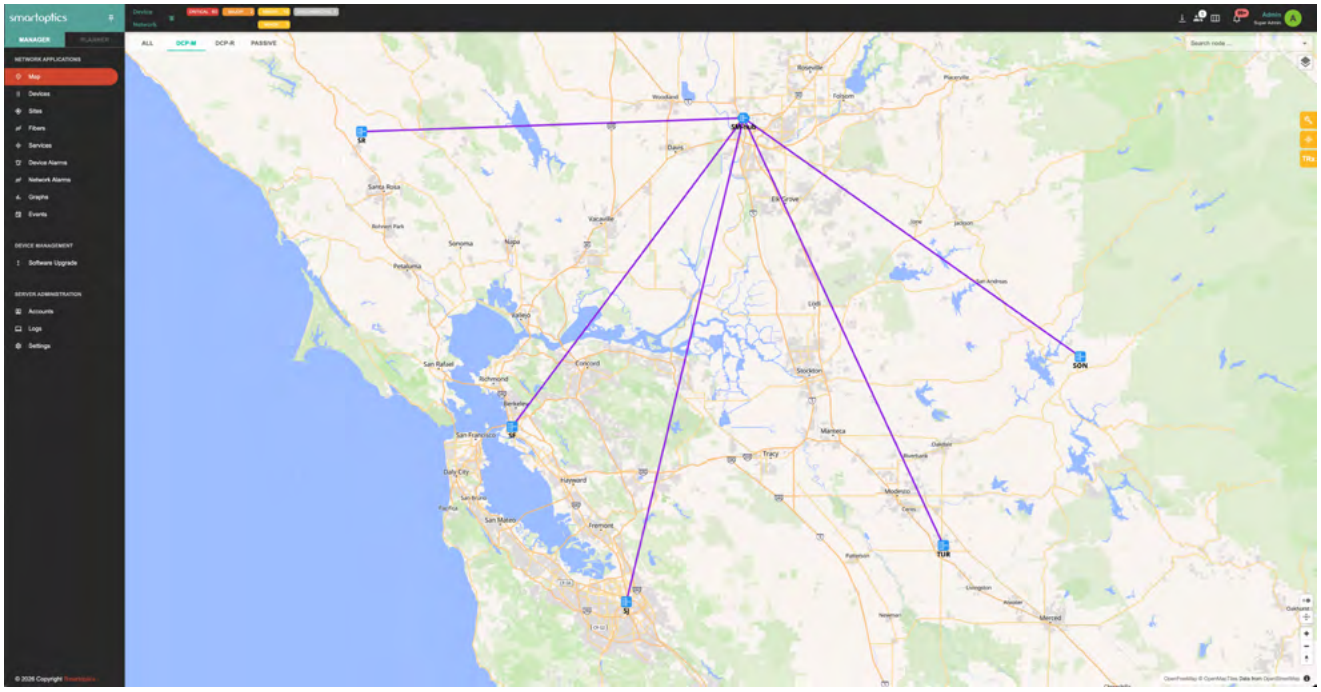



Figure 12. The SoSmart Manager graphical user interface

# About Smartoptics

Smartoptics provides innovative optical networking solutions for a new era of open networking. We focus on solving network challenges and increasing the competitiveness of our customers. Our customer base includes cable and telecom operators, cloud providers, Internet exchanges, governments, and thousands of enterprises.

At Smartoptics, we leverage modern software design principles and expand network horizons by taking an open approach in everything we do. This empowers our customers to break free from unwanted vendor lock-in, remain flexible, and minimize costs.

Our solutions based on open networking standards and protocols are used in metro and regional network applications as well as in metro access networks. The products we deliver are based on in-house developed hardware and software and enhanced by associated services.

Smartoptics is a Scandinavian company founded in 2006. We partner with leading technology and network solution providers and hold numerous certifications and approvals from major switching and storage solution providers such as Brocade, Cisco and Dell. We have a global reach through our salesforce and more than 100 business partners including distributors, OEMs and VARs.

As a challenger, we take pride in our open approach, smart design principles and ambitious customer service.

For additional information about Smartoptics, please visit us at https://www.smartoptics.com/

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