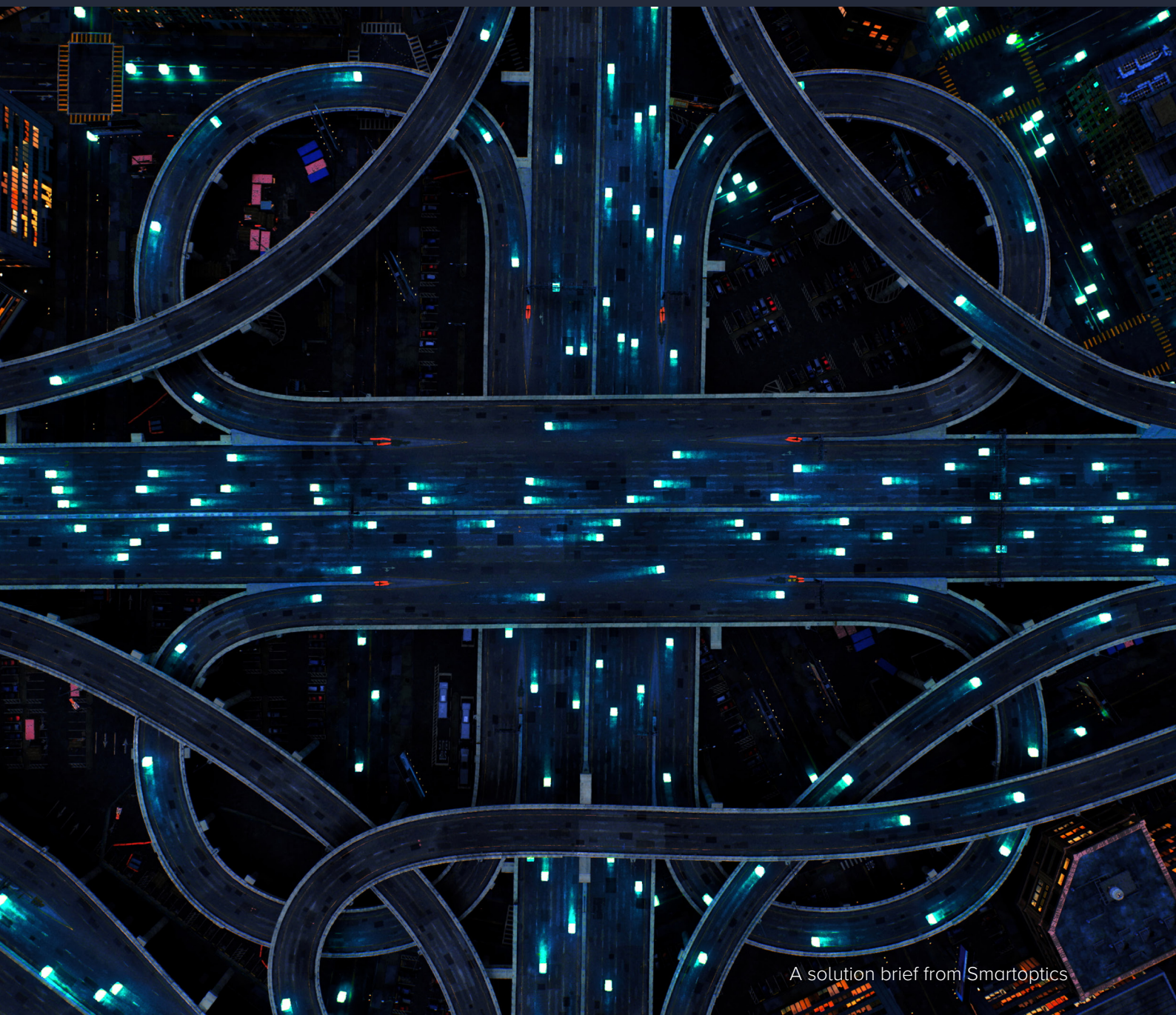
smartoptics

Open Line Systems with ROADMs from the DCP-R Family



A solution brief from Smartoptics

Using ROADMs is since long the standard method to enable flexible add/drop of wavelengths in optical networks with ring and mesh topologies. Having an open architecture and support for multiple traffic formats, the Smartoptics DCP-R Family allows you to implement virtually any type of ROADM-based network topology, disintegrating the once monolithic optical platforms into open line systems and switches with embedded transceivers, an ideal solution for IP over DWDM.

Smartoptics ROADM Portfolio

Being a pioneer in open line systems, it is a natural step for Smartoptics to also offer a portfolio of ROADMs using the same open and disaggregated architecture. If you want to leverage the current breakthroughs in DWDM transceiver technologies and associated cost reductions it is a must to go for an open approach where the transceivers are embedded in standard switches and where the routing of the optical wavelengths is done by an open line system.

ROADM-based metro/regional and metro access networks can easily be built by the Smartoptics DCP-R family of dedicated ROADMs, by the DCP-F family of versatile active optical units, or by a combination of both families.

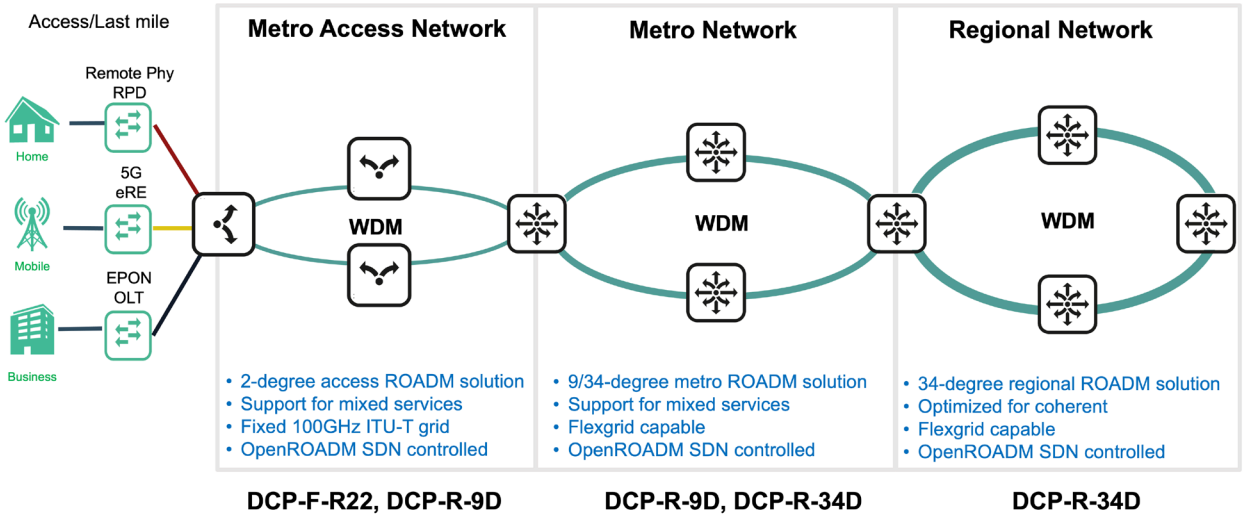


Figure 1. Smartoptics ROADM Portfolio

The DCP-R-*n*D is a family of all-in-one ROADMs for 2- to 34-degrees, spanning applications from the metro access network up to large regional and national networks. The DCP-R family comprises compact, 1 RU per degree ROADMs having Flexgrid support and colorless, directionless, and contentionless capabilities. The DCP-R ROADMs are true multipurpose units, designed for use with coherent modulation formats as well as legacy NRZ modulation formats, while supporting Ethernet and Fibre Channel traffic. The DCP-R ROADMs come in the same compact enclosure as the well-known Smartoptics DCP-M family.

The DCP-F-R22 and DCP-F-A22 are two extremely versatile active optical units for configuration of any type of optical network at the lowest possible cost. Their main application as ROADMs is as 2-degree ROADMs in metro access ring networks and generally where low cost and seamless interworking with the passive parts of the network are a prerequisite for deployment. The DCP-F-A22 can also play an important role as inline amplifier in networks built with DCP-R. For additional information on the DCP-F family, see the DCP-F Family Solution Brief, available at https://www.smartoptics.com/

The DCP-R Family

The guiding principles when designing the DCP-R ROADMs have been to create a standards compliant, truly open line system, manageable in an SDN context, and capable to support all major modulation formats in any chain, ring, or mesh network topology. The DCP-R ROADMs were also developed in close cooperation with Smartoptics' customers and in line with the target architecture for disaggregated open optical networks as outlined by the major European Telecom operators in the Telecom Infra Project (TIP).

> *The DCP-R ROADMs were also developed in close cooperation with Smartoptics' customers*

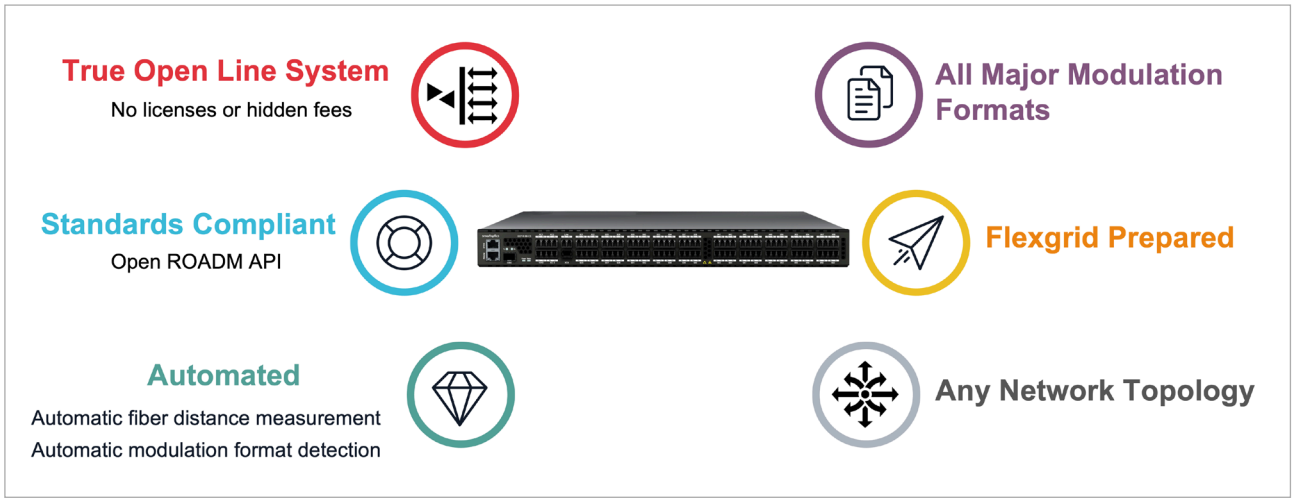


Figure 2. High level features of the DCP-R ROADMs

In the TIP architecture the once monolithic and vendor specific DWDM system is disintegrated into separate network elements, i.e., into optical line terminals, multiplexers, ROADMs, and amplifiers, each being controlled by a common SDN domain controller via open API:s such as NETConf or gNMI. This truly open architecture is ideally suited for IP over DWDM applications where transponders and muxponders are used only when they are required to add value. A further advantage of this approach is that optical elements from best-of-breed vendors can be mixed and matched to take advantage of the rapid development and different lifecycles of the products making up the optical infrastructure. In short: Open and disaggregated optical systems enables the operator to manage multivendor networks and to pick the most suitable open network elements from arbitrary vendors.

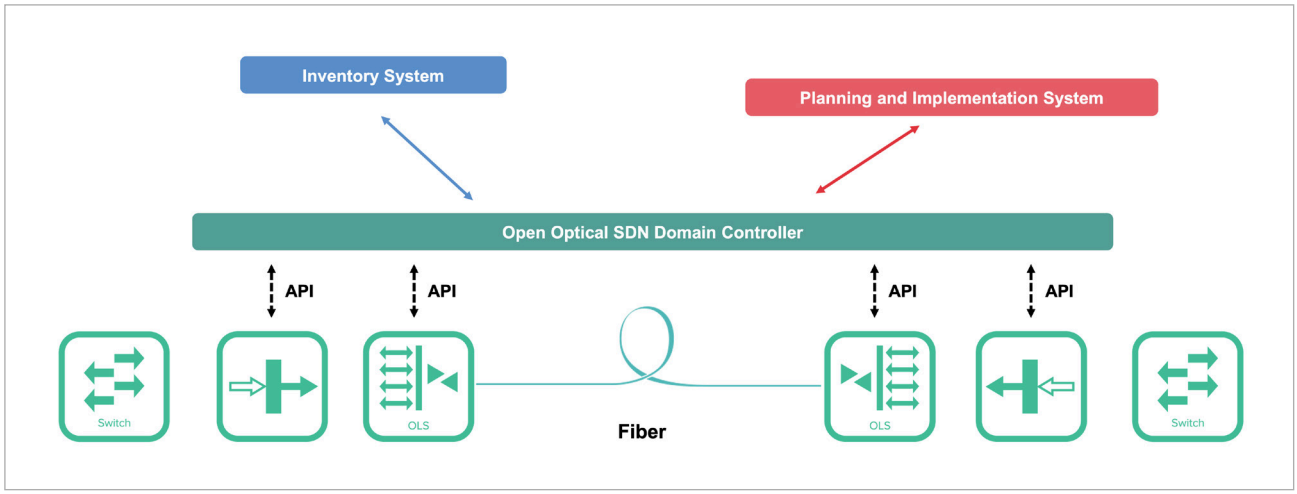


Figure 3. The TIP model for disaggregated optical networks

The DCP-R family comprises the 9-degree ROADM DCP-R-9D and the 34-degree ROADM DCP-R-34D. Each ROADM comes in the same compact 1 RU enclosure as the well-known Smartoptics DCP-M family of open line systems. This “all-in-one-box” design brings several advantages, such as lower total cost due to shared processors, power feed etc., and simplified fiber management by minimizing the risk for incorrect connections and dirty fiber connectors. Furthermore, one DCP-R per ROADM degree provides full hardware redundance for each fiber direction and a standardized solution for all node directions.

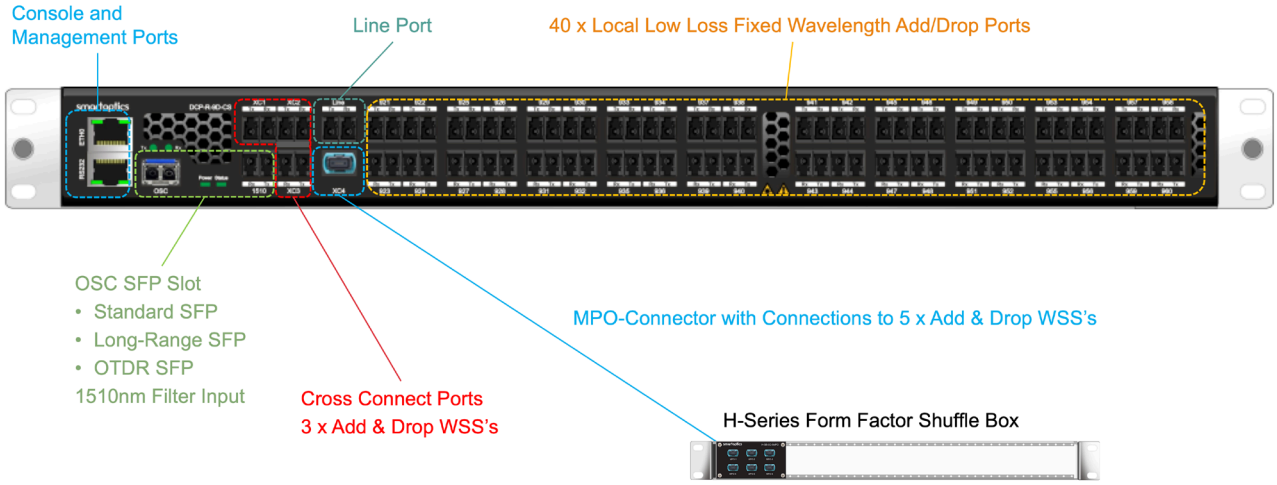


Figure 4. The DCP-R-9D Front Panel

ROADM Benefits

ROADMs (Reconfigurable Optical Add/Drop Multiplexers) are used in bus, ring, and mesh shaped optical networks to enable flexible add/drop of individual wavelengths and for adding of new wavelengths without affecting the traffic on adjacent channels. The flexibility of ROADMs thus benefits the operator wanting to adapt to changing service requirements as well as overall network availability by simplifying protection switching and restoration of light paths. ROADM nodes also bring significant advantages from a network planning perspective. The free wavelength allocation with ROADMs simplifies traffic engineering and thereby reduces the effects of inaccurate traffic forecasting. In addition, ROADMs can perform automatic power balancing and simplify the structure of the physical network, thereby greatly simplifying fiber management.

ROADMs are typically designed around 1xn Wavelength Selectable Switches (WSS) and multiplexers, as shown in the illustration below. The number of optical fiber link directions to/from a ROADM is commonly referred to as the degree of the ROADM, for example the add/drop nodes of a ring network are often 2-degree ROADMs. Further flexibility can be given to the ROADM by making the mux/demux ports wavelength independent, i.e. making it possible to add/drop any wavelength at any port, creating a colorless ROADM. By adding further components, the ROADM can allow for switching of any wavelength in either the “east” or “west” direction (directionless ROADM) and for the re-use of wavelengths that have been dropped in one direction in the continued light path (contentionless ROADM). Modern ROADMs are often capable of all the above, being Colorless, Directionless, and Contentionless (CDC) at the same time.

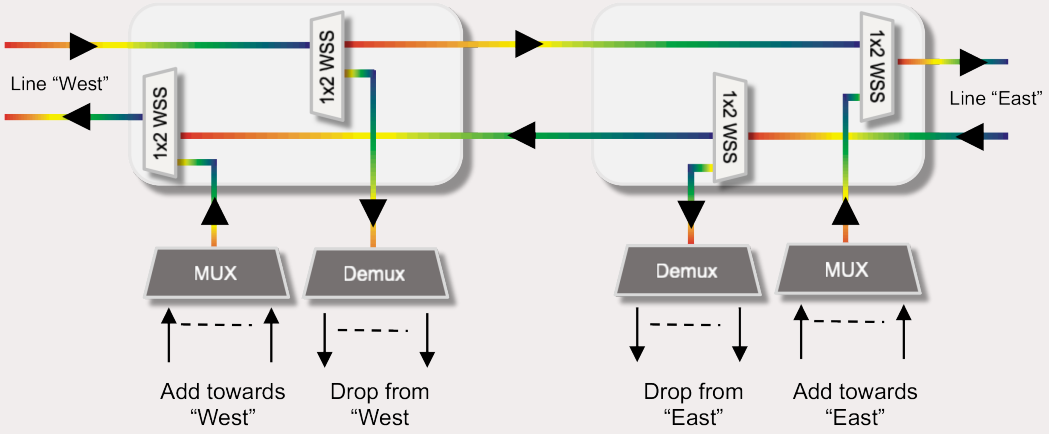


Figure 5. The main components of a 2-degree ROADM node

All DCP-R ROADMs support a high level of automation and openness. No extra licenses or fees per added wavelength are required. The ROADMs are typically controlled through the NETConf or gNMI protocols compliant with the principles outlined by the OpenROADM MSA architecture and with TransportPCE as the SDN controller. The configuration of the ROADMs is further simplified by the integrated, automatic fiber attenuation and distance measurement. A natural choice for managing the DCP-R ROADMs is the Smartoptics SoSmart Software Suite which provides extensive management and planning capabilities for the optical domain.

All DCP-R ROADMs support a high level of automation and openness.

The DCP-R family supports a mixture of traffic formats with completely automatic detection of the modulation used and have Flexgrid, directionless, contentionless and colorless capabilities, all built on the scalable and cost effective DCP platform ensuring small footprint and low power consumption.

The DCP-R ROADMs are ideally suited for chain, ring, and meshed network topologies. They come with internal optical amplifiers (EDFAs) and additional inline optical amplifiers from the DCP-F family can easily be added for longer reach.

Traffic Formats and Modulation Support

A prominent characteristic of the DCP-R family is the great flexibility with which modulations and traffic formats can be mixed within the same ROADM. This unique flexibility of the DCP-R family allows for efficient handling of legacy formats while offering an excellent upgrade path when new traffic formats based on new technologies are introduced in the network.

This unique flexibility of the DCP-R family allows for efficient handling of legacy formats.

The DCP-R ROADMs support both legacy NRZ modulated wavelengths (1-10G Ethernet, 1-32G Fibre Channel, CPRI 1-10, SONET, SDH, OTN, etc.) and newer coherent modulated formats. When it comes to coherent modulation all existing formats, having data rates from 100G to 400G, including 400ZR, as well as 800G and beyond are supported. The achievable optical reach on the optical links is traffic format dependent as well as network design and DCP-R model dependent. Further information on the optical performance of the DCP-R family can be found in the data sheet for each model.

Functional Design

The DCP-R-9D is an extremely compact, 1 RU per degree, 9-degree ROADM with a built-in 40 channel mux/demux for local add/drop. Additional colorless add/drop ports may easily be added through an external Smartoptics H-series fiber shuffle box.

The DCP-R-9D is an extremely compact, 1 RU per degree, 9-degree ROADM with a built-in 40 channel mux/demux for local add/drop.

The following illustration shows the block diagram of the DCP-R- ROADM.

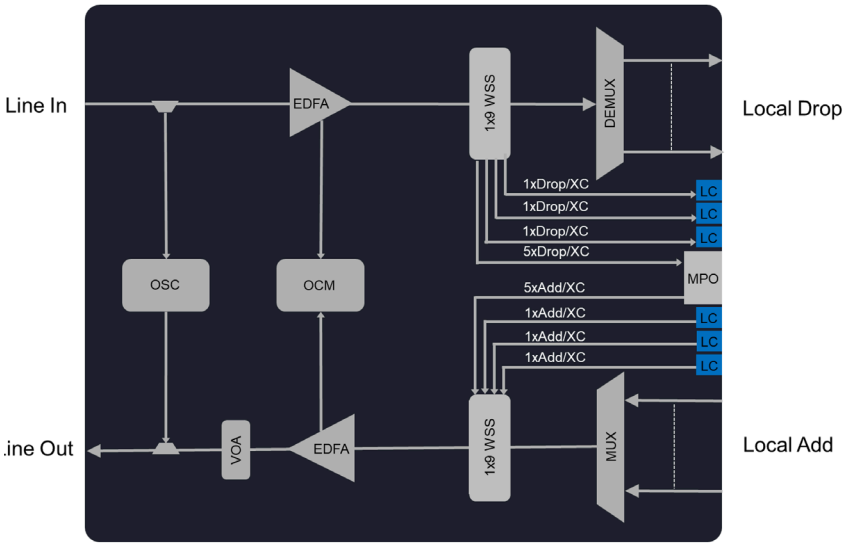


Figure 6. Block diagram of the DCP-R-9D

The DCP-R-34D is also a compact, 1 RU per degree, 34-degree directionless, contentionless, and colorless ROADM with Flexgrid support. The DCP-R-34D provides direct access to 34 WSS ports for local add/drop of wavelengths or express wavelengths. All 34 ports are colorless by design. A variable gain optical amplifier is used as pre-amplifier providing an extended reach. An even further reach can be achieved by combining the ROADM with the Raman amplifier DCP-F-RA12 from the DCP-F family.

The following illustration shows the block diagram of the DCP-R-34D ROADM.

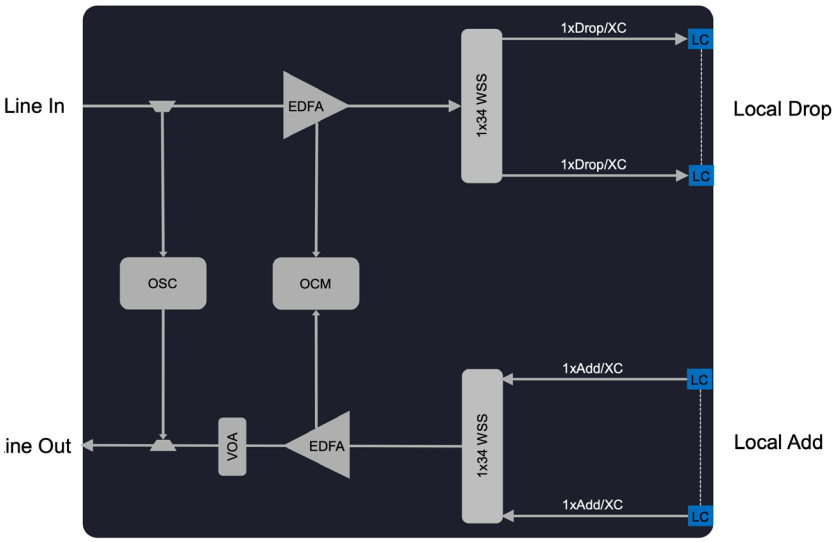


Figure 7. Block diagram of the DCP-R-34D

Management of all members of the DCP-R family is either done by an SDN controller through the OpenROADM based API or manually by parameter settings from a command line interface (CLI).

Optical Time Domain Reflectometer SFP Support

The DCP-R ROADMs support the use of special OTDR SFP transceivers acting as optical time-domain reflectometers (OTDRs). 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.

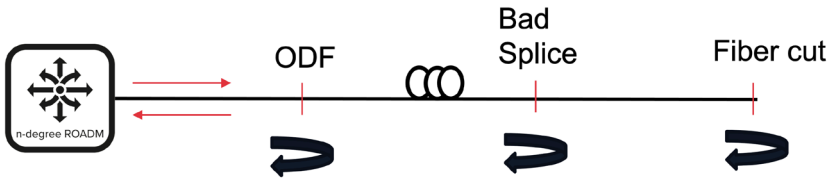


Figure 8. Optical Time Domain Reflectometer (OTDR)

The special pluggable transceiver from Smartoptics is a combined Optical Supervisory Channel (OSC) and OTDR SFP operating at the 1511 nm wavelength and capable of measuring reflection points at a distance up to 100 km with an accuracy of 50 m or better.

ROADM Applications

A typical use case for ROADMs is to be deployed in metro ring networks aggregating traffic from multiple points of presence (PoP) towards hub nodes which are forwarding the traffic to the regional or national network. Such rings are easily created by a set of DCP-R-9D operating as 2-degree ROADMs.

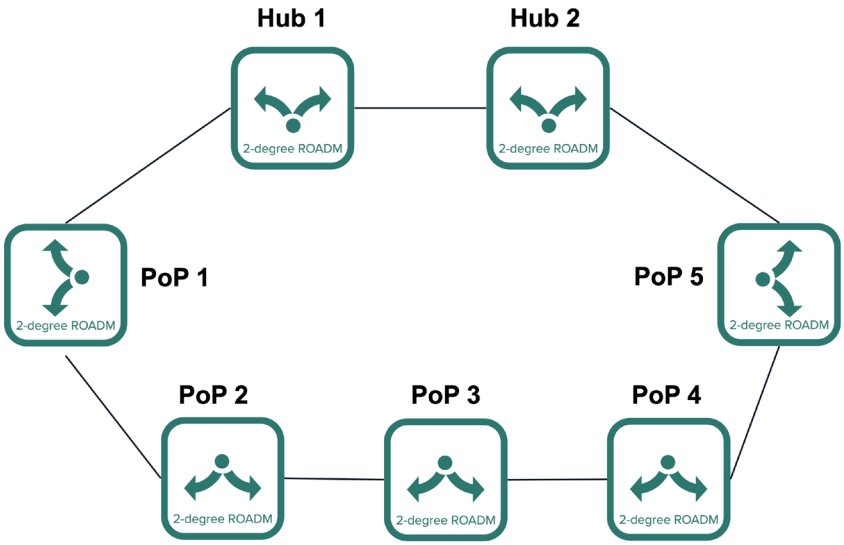


Figure 9. Ring network with 2 Hubs and 5 Points of Presence

ROADMs are also the natural choice when building larger regional and national networks. These networks normally consist of multiple rings in a meshed topology, requiring ROADMs of higher degrees and making the DCP-R-34D a perfect fit. When longer distances are involved, such regional networks often comprise both ROADM and inline amplifier nodes, sometimes also RAMAN amplifiers for extended reach.

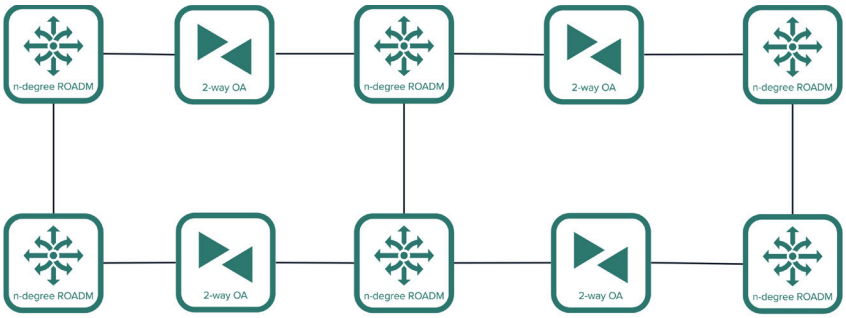


Figure 10. Meshed regional network with ROADM and inline amplifier nodes.

2- and 4-degree ROADM Configurations

When the DCP-R-9D is used in a typical 2-degree ROADM configuration, two of the ports of the WSS are used for the optical connection to the adjacent ROADM in the node, as shown in the following illustration.

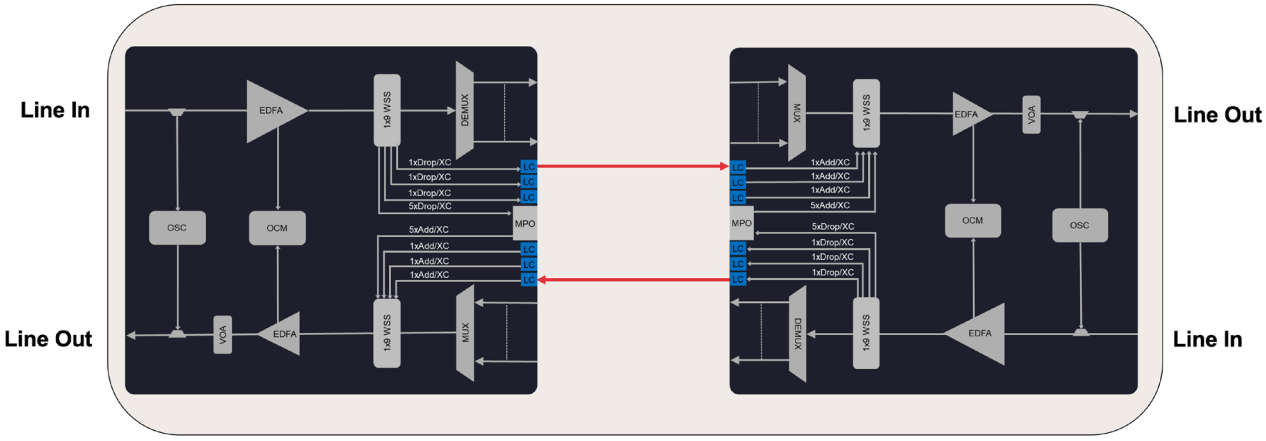


Figure 11. Typical 2-degree ROADM node with DCP-R-9D

The remaining seven WSS ports of the DCP-R-9D (two accessible via LC connectors and five via an MPO connector) can be used for:

- Direct connection of coherent wavelengths to the WSS
- Connection to a colorless filter
- Connection to a full Connectionless, Directionless, Colorless (CDC) filter (Amplification may be required depending on the number of channels.)

The following illustration shows a complete ring where the DCP-R-9D is used as a 2-degree ROADM. Due to the multiformat support and automatic modulation detection of the DCP-R-9D it is extremely easy for the operator to offer and manage multiple services with different traffic formats between individual add/drop sites.

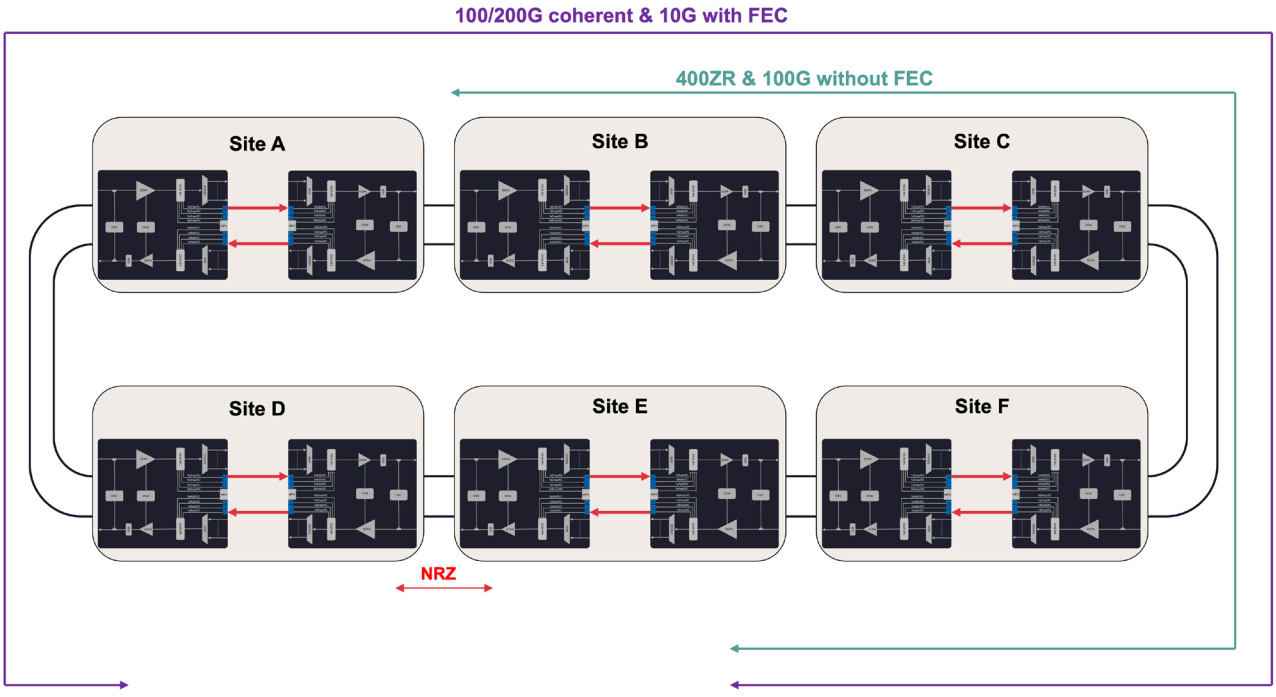


Figure 12. A complete ROADM ring with support for multiple traffic formats between individual sites

A 4-degree ROADM node is easily built by combining four DCP-R-34D ROADMs as depicted in the next illustration. As for the 2-degree ROADM case, the free WSS ports may be used for direct connection of coherent wavelengths for colorless operation or for connections to a colorless or full CDC filter.

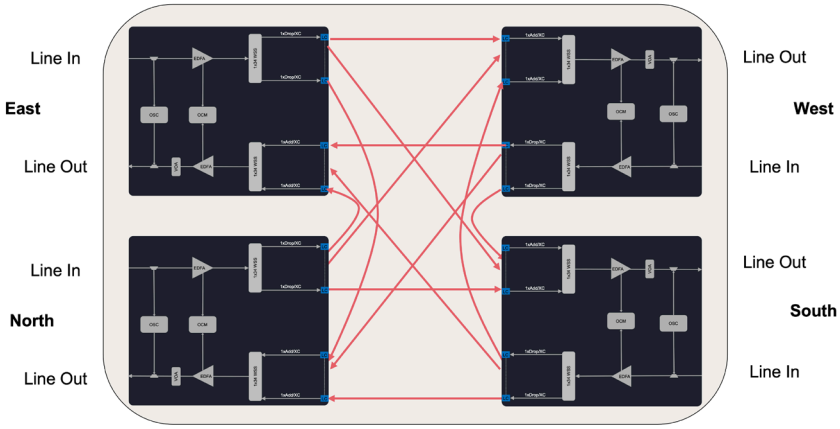


Figure 13. A 4-degree ROADM node with DCP-R-34D

Access, Metro and Regional Networks

The DCP-R-9D and DCP-R-34D ROADMs can easily be combined, for example when deploying a regional and metro optical network. As shown in the illustration below, DCP-R-34D ROADMs form the principal regional ring and the metro rings are then connected to the regional ring by use of a 4-degree ROADM, implemented by DCP-R34D and DCP-R-9D ROADMs. Since all network elements use the same DCP platform from Smartoptics, management is greatly simplified while maintaining the open line systems architecture.

> *The DCP-R-9D and DCP-R-34D ROADMs can easily be combined.*

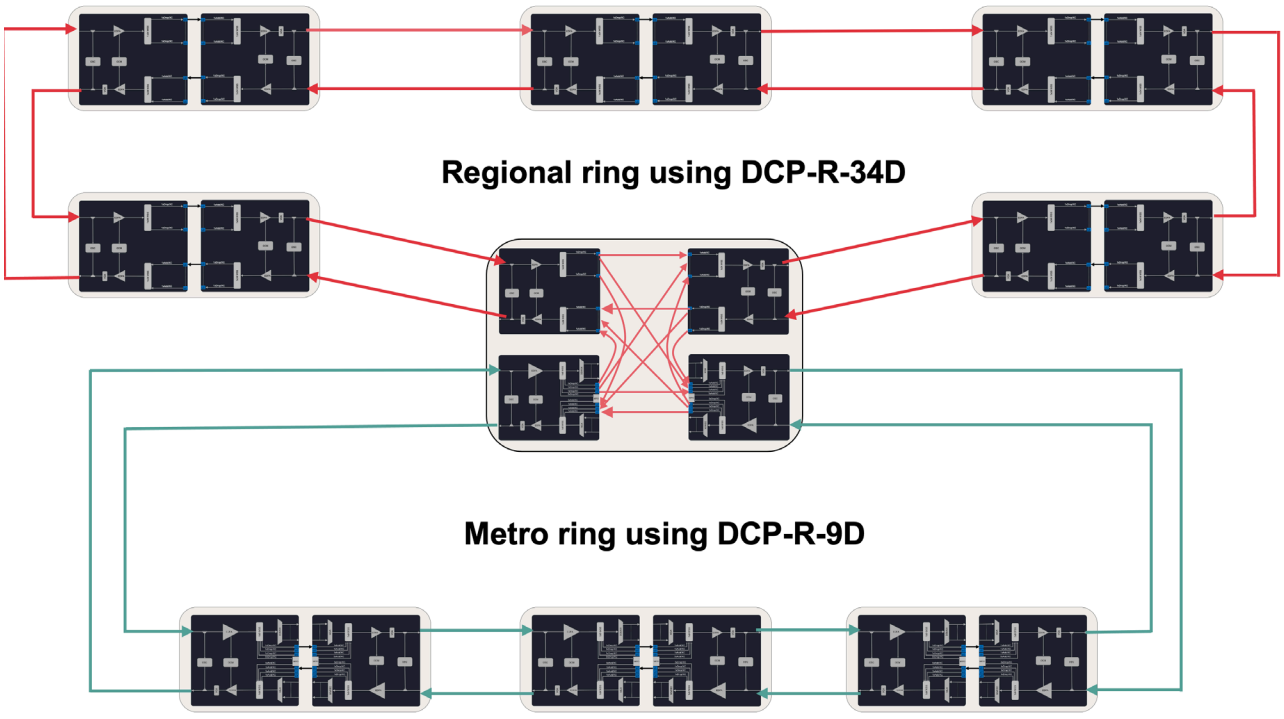


Figure 14. A regional and metro network implemented by use of DCP-R-34D and DCP-R-9D.

The DCP-R ROADMs can also be combined with and DCP-F family products when longer distances need to be bridged and amplification of the optical signal is required. The dedicated DCP-F-A22 Optical Line Amplifier (OLA) with the necessary EDFA module is then inserted as signal regenerator at suitable intermediate locations.

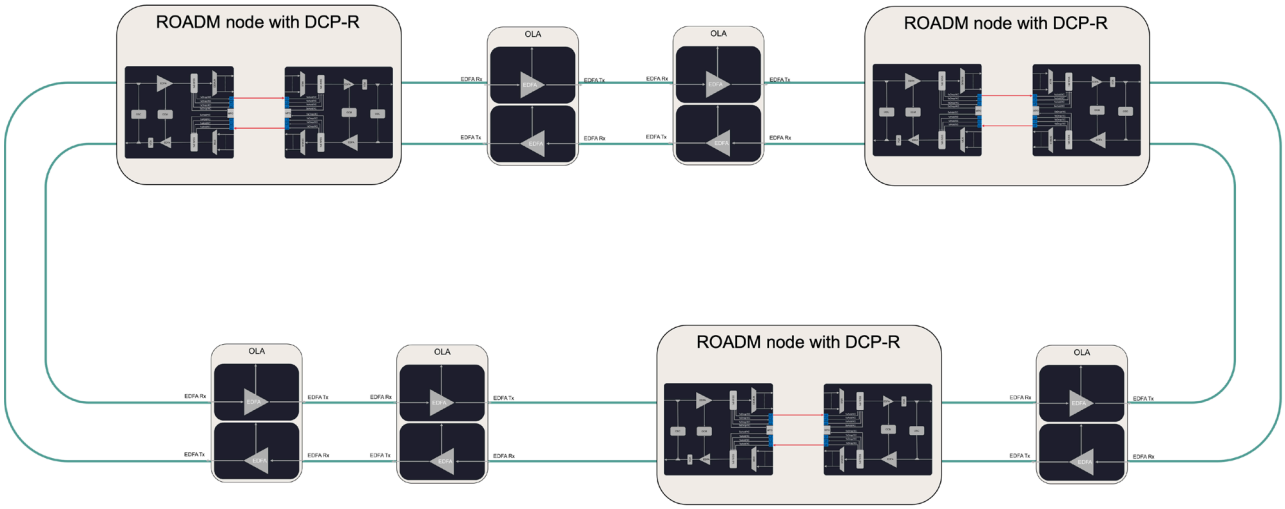


Figure 15. An example using DCP-F-A22 used for signal amplification and regeneration.

The DCP-SC-28P Shelf Controller

A complete Smartoptics ROADM node comprises one or more DCP-R units and a DCP-SC-28P shelf controller. The shelf controller manages the DCP-R units and acts as the interface towards the management system. The common shelf controller off-loads the processors embedded in the ROADM units and makes it possible to manage all ROADM units in the node under one single IP address. The shelf controller also provides the IP routing (OSPF) required for failover management. In addition, the shelf controller may be used for management of external transponders or other types of external equipment.

The DCP-SC-28P shelf controller does not take part in any optical traffic processing, which means that it can be updated and even replaced without affecting the ongoing traffic at all. This leads to a longer life for the node ROADMs since their internal processors will not limit the node functionality. Should more demanding processing or more memory be needed in the node, it is just a matter of upgrading the shelf controller.

> *The DCP-SC-28P shelf controller can be updated and even replaced without affecting the ongoing traffic at all.*

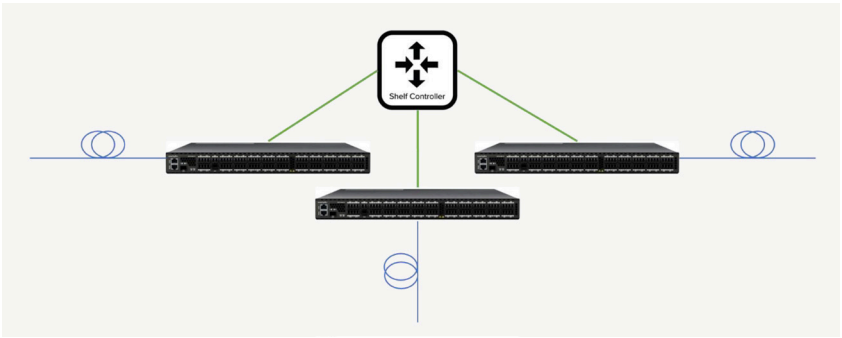


Figure 16. The ROADM node equipment is managed via a common shelf controller

The shelf controller is an integral part of the secure IP network (DCN) used for the management of the individual ROADM nodes installed.

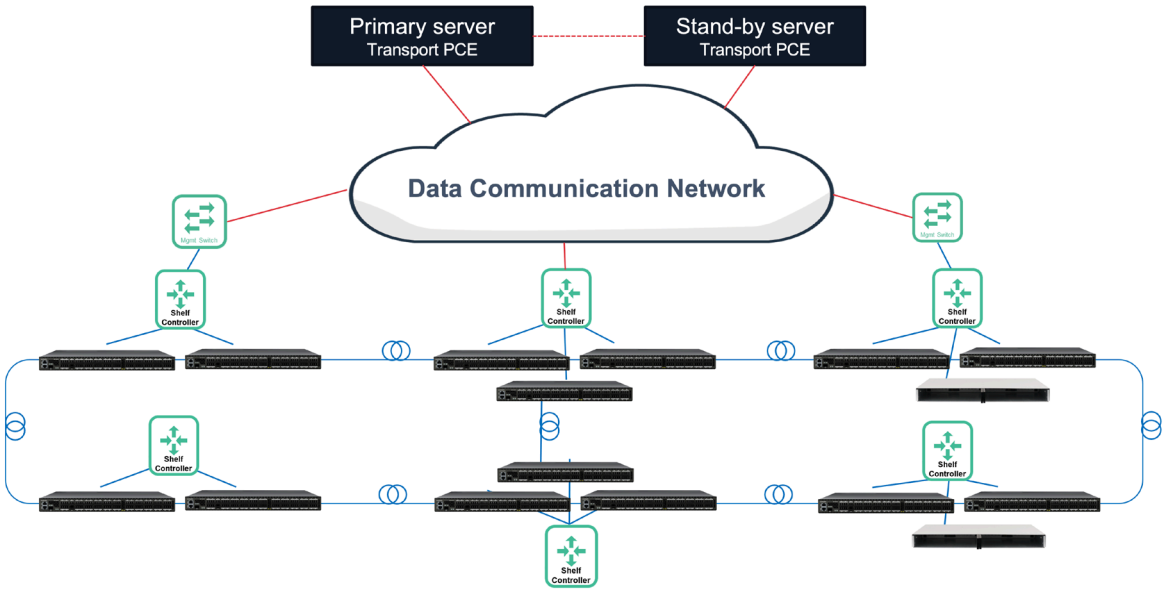


Figure 17. A complete IP network for ROADM node management

Network and Wavelength Management

Looking at the total life cycle cost of a communications network, the recurring operational and management expenses dominate. Capable network management tools and network equipment designed for cost efficient maintenance are vital to make the communication network investment profitable and the business case attractive.

An open optical network requires a similarly open approach to network management. Where traditional optical transport system vendors have built proprietary software architectures for management of their own hardware, Smartoptics products provide open APIs that allow the customer to leverage open-source solutions available today, develop their own applications on open SDN platforms or buy complete management solutions from other commercial players.

> *An open optical network requires a similarly open approach to network management.*

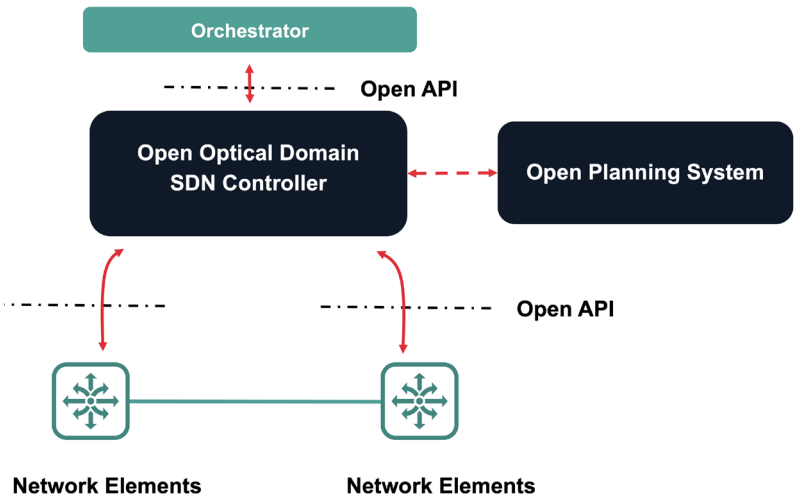


Figure 18. Smartoptics open network management architecture

The Smartoptics SDN based and open API approach to network management is fully in line with the architecture for disaggregated open optical networks as outlined by the major European Telecom operators in the Telecom Infra Project (TIP).

Disaggregating the traditionally monolithic management solution brings several advantages. Rather than being dependent on the functionality and evolution of any vendor specific management platform, you may now leverage the more rapid advances of an open-source effort such as the TransportPCE SDN controllers. Furthermore, an open management approach radically simplifies the integration of network elements from multiple vendors under the same SDN controller, thereby reducing the risk of any vendor lock-in. It also gives you a much higher degree of flexibility in designing the network management solution and adopting it to the optimal workflow for your organization. With open management APIs in the network elements, you can go for anything from a sophisticated integration with your own SDN based applications to using a simple command line interface. Any development of customer specific software to manage a network is thus considerably less complicated in this modern and open environment than for a closed architecture, which is restricted by proprietary software functions tightly embedded in the network elements.

A Focus on Automation

Smartoptics traditional focus has been on the corporate data center interconnect (DCI) market where a high level of automation (plug&play) is greatly appreciated by our customers. Automation aspects are therefore particularly important to us, and we are convinced that such operational benefits are of value to all our customers. We are hence designing for as much automation capabilities as possible within our products, both when used “stand alone” and in an SDN framework. Concrete examples are the automatic fibre distance and attenuation measurements and the automatic modulation format detection in the DCP-R family of ROADMs. Amplifier gain and variable attenuator settings are also automated when the SoSmart Software Suite is used.

Management Architecture and Implementation

The DCP-R and DCP-F product families, often deployed in operator networks, are designed to be externally managed. The external management can either be via a command line interface (CLI) or by using Software Defined Networking (SDN) principles based on the OpenROADM MSA initiative. Depending on customer requirements management may be done directly from the customer´s already existing SDN controller/ orchestrator via the OpenROADM APIs of the network elements, by the Smartoptics SoSmart controller and the customer´s orchestrator or by the full Smartoptics SoSmart Software Suite, including the SoSmart Manager with a complete GUI, optical provisioning, and full FCAPS functionality. The availability of CLI and SDN-based management for each individual DCP product is release dependent.

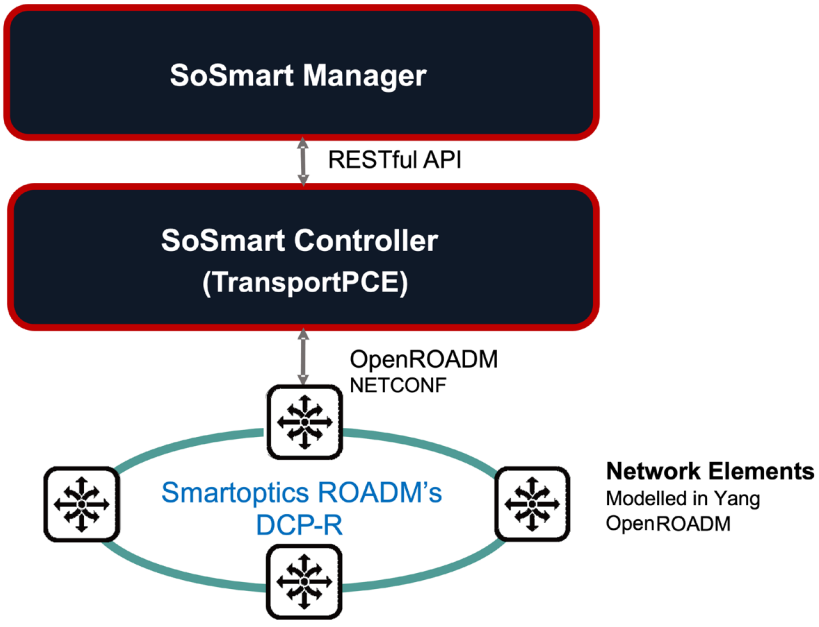


Figure 19. The SoSmart Software Suite from Smartoptics

The Smartoptics SoSmart complete SDN software suite for open network management has a modern and hierarchical architecture that enables management flexibility, modularity, multiple integration possibilities, and openness. The software suite includes the following building blocks:

- Software embedded in the DCP network elements with data models based on Yang and supporting the OpenROADM API's, which are made accessible via the NetConf protocol
- The SoSmart Controller – An open source SDN controller based on TransportPCE
- The SoSmart Manager – A network management system with graphical user interface, optical provisioning and full FCAPS functionality
- The SoSmart Planner – An offline, optical simulation tool based on the open source GNPy

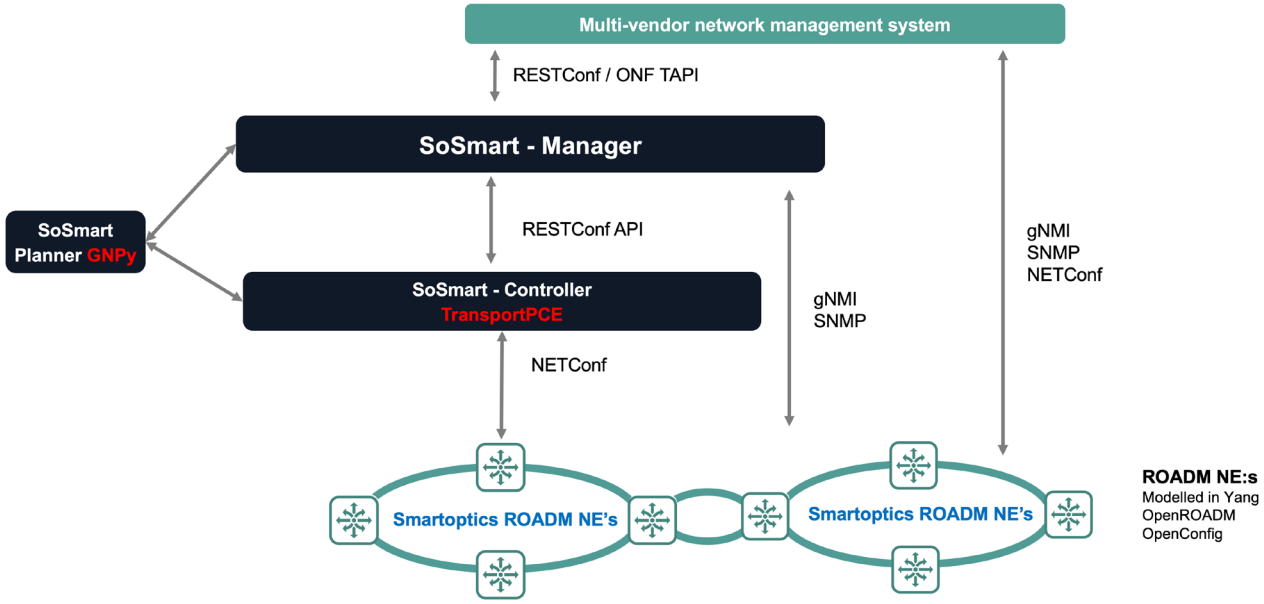


Figure 20. High level overview of the SoSmart Software Suite entities

Summary

The DCP-R family offers you a simple and straight forward way to leverage the benefits of open optical networking when implementing virtually any type of ROADM-based network topology. The family supports both new coherent traffic formats and 400ZR modulation as well as legacy formats such as Ethernet, Fibre Channel, SONET, SDH, and OTN including automatic fiber distance measurement. Modulation type is automatically detected, and the ROADM is typically controlled through an OpenROADM compliant API via NetConf from an SDN controller. All DCP-R family members are designed for the highest level of quality and simplicity in use – a given choice for your network.

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.

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

smartoptics

Ryensvingen 7
NO-0680 Oslo
Norway
+47 21 41 74 00

info@smartopics.com
smartoptics.com