Connectivity in a world of data centers

A new era of data center interconnect

ADVA™
Optical Networking

Different types and their different needs

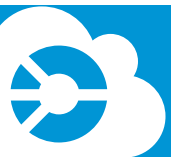
Data center interconnect (DCI) has emerged as the main driving force for innovation in the optical networking industry. The phenomenal growth in internet traffic and the fierce migration to cloud-based services in recent years are combining to force a dramatic rethink of how data centers are connected. In a broad sense, there are two basic types of data centers: private, company-owned, enterprise data centers and outsourced facilities owned by data center providers. And this is where it gets interesting. While the needs of interconnecting data centers are clearly different to those of traditional, network operator-owned optical transport infrastructure, different types of data centers and their different tasks impose further, substantially different and new requirements on optical DCI.

Old and new world

You can make the case that traditional enterprise data centers targeting disaster recovery and business continuity applications haven't changed much in the past ten years. They have just been retrofitted with faster network connections and better security in various stages of implementing virtualization with storage subsystems of various types. In the world of outsourced data centers and especially those owned and operated by internet content providers (ICPs) a lot has changed. There are a multitude of purpose-built data centers, ranging from content-based hyper-scale data centers, colocation and peering providers, financial and supercomputing application data centers, and cloud or shared data centers. You could also include central offices owned by network operators, which will be designed like data centers in the near future. All have their specific requirements when it comes to interconnect.

Openness is part of the future

Today, DCI is focusing on more than the stringent set of demands for density, scalability and energy consumption. Open solutions featuring open protocols, hardware and software interfaces for scaling best-of-breed, multi-vendor networks have become the center of attention. Data center operators have already started to integrate transport connections among data centers into orchestration software running on their own internal networks by using software-defined networking (SDN) and open application programming interfaces (APIs). Software-based programmability and ease of integration have become critical, but often overlooked factors.



Emerging data center architectures demand platform diversity

Disaster recovery and business continuity

As the data center has become a strategic issue, enterprises need to ensure protection against impending risks of cybercrime, natural disasters and terror attacks. Your digital information needs to be backed-up and made easily accessible to your employees and customers even if disaster strikes. The design of the optical network interconnecting primary and back-up facilities for your private cloud, transaction systems, data repositories and other applications is a critical resource to ensure such disasters have as little impact as possible. It is, therefore, essential to give your company the best chance of coming out of a crisis unscathed.

Highest availability for all applications

Our FSP 3000 is fully qualified to interoperate with all major storage area network (SAN) and server solution providers. It supports all Fibre Channel standards including 32G FC and provides lowest-latency transport for any distance. In fact, it is now the underlying connectivity solution for many of the world's leading disaster recovery and business continuity implementations. To deliver a complete solution for enterprise DCI applications, our FSP 3000 can also drive InfiniBand and various other protocols over distance at lowest latency and highest quality of service failover.

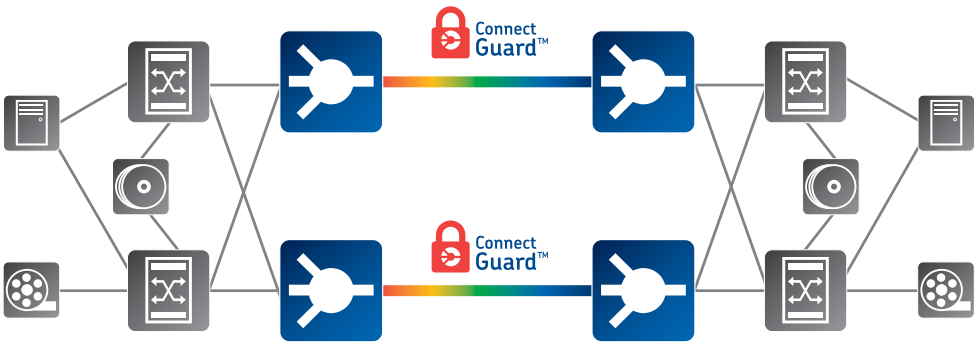
> “Connectivity for mission critical data center applications”

Efficiency everywhere

Every aspect of our FSP 3000 has been engineered to be as efficient as possible. Each of our configurable chassis share an incredibly small footprint. They consume less rack space than any competing technology. They also consume less energy – a lot less energy! What's more, our FSP 3000 helps to reduce inventory sprawl. Our chassis share the same line cards. This means deploying the same technology in your data centers, your colocation sites and your smaller offices.

Encryption at the speed of light

Our ConnectGuard™ solution has been specifically engineered to protect your data wherever it is in the network. To achieve such comprehensive protection, our ConnectGuard™ technology is designed primarily for DCI applications that need to transport enormous amounts of data across geographically dispersed locations. It provides robust low-latency encryption across line speeds of 100Gbit/s and beyond, and eliminates the need for standalone security equipment.



High availability and redundancy

Interconnecting hyper-scale data centers

Today's networks built to interconnect hyper-scale data centers are reaching a critical juncture. The phenomenal growth in internet traffic combined with the fierce migration to cloud-based services is forcing a dramatic rethink of how hyper-scale data centers are connected. Current DCI networks are proving to be bottlenecks and are severely limiting growth. For ICPs and carrier-neutral providers (CNPs) to continue to meet customer expectations and drive efficiencies within their data centers, they need to build optimized DCI infrastructures that are scalable, efficient and secure.

Unlimited scalability

Our FSP 3000 CloudConnect™ provides a scalable solution that can meet increasingly stringent data demands. It can transport up to 25.6Tbit/s duplex capacity per fiber pair from a single rack, delivering 1.4Tbit/s of total throughput per rack unit. Available in multiple configurations, including a four rack unit chassis, our DCI technology features the industry's first true 400G single line card with no active backplane lock-in. There's also no client port lock-in. As new Ethernet data rates emerge, they can be plugged straight in.

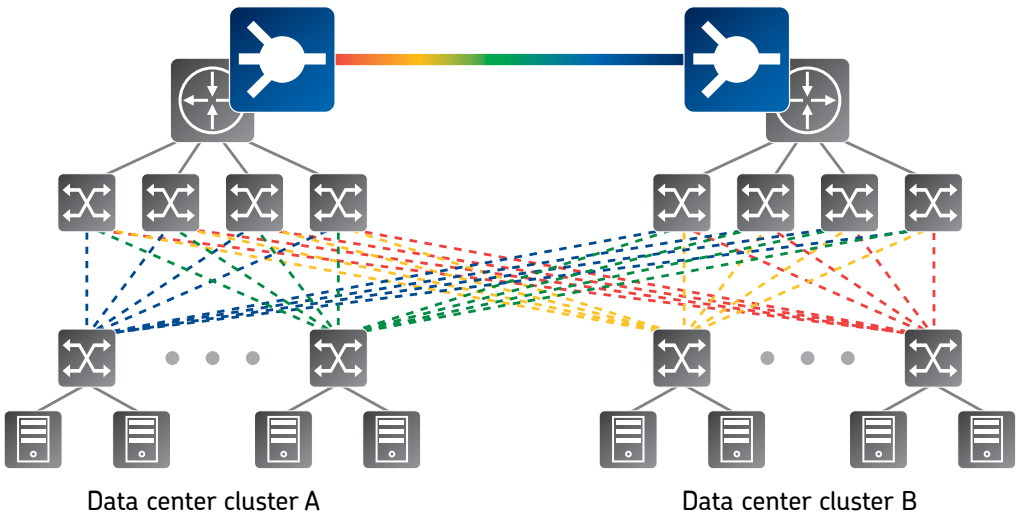
Open line system flexibility

Our FSP 3000 CloudConnect™ offers the industry's only truly open DCI solution. It offers both open line system (OLS) hardware and open APIs to support real best-in-breed networks. It enables ICPs and CNPs to deploy a simplified DCI solution that contains just the functions required to link two data centers together at either metro or long-haul distances. The OLS of our FSP 3000 CloudConnect™ can carry any wavelength service regardless of modulation format, data rate or client system.

Balancing cost with spectral efficiency

In today's networks interconnecting hyper-scale data centers, there is no one size fits all. ICPs and CNPs have radically different demands and need solutions that reflect their specific requirements. Spectral efficiency, price, space and power are four critical building blocks that must be optimized to meet your key objectives. Whether you are in the backbone or in the metro, our FSP 3000 CloudConnect™ offers modulation formats to suit your specific needs, ranging from spectrally highly-efficient coherent detection to low-power, low-footprint direct-detect solutions.

> "Enabling a hyper-efficient data center environment"



Cloud data center interconnect

DCI for the telco transformation

Network operators face significant challenges supporting ever-increasing bandwidth demands and service expectations. At the same time, introducing a new feature often takes months and sometimes years. In response to these challenges, network operators have started to re-architect their central offices as data centers to benefit from both the economies of scale and the agility that ICPs and cloud providers enjoy today. The new, data center-like architecture combines SDN, network functions virtualization and elastic cloud services, all running on commodity hardware to build cost-effective and agile networks that enable rapid service creation and monetization.

Introducing CORD

The central office re-architected as a data center (CORD) community has proposed a new architecture not only focusing on replacing today's purpose-built hardware devices with their more agile software-based counterparts, but also making the central office an integral part of every telco's larger cloud strategy. The reference implementation of CORD includes specific choices for all hardware elements, organized into a rack-mounted unit. The software building blocks follow an open systems architecture and exploit four open source projects, enabling network operators to offer more valuable services, i.e. OpenStack, Docker, ONOS and XOS.

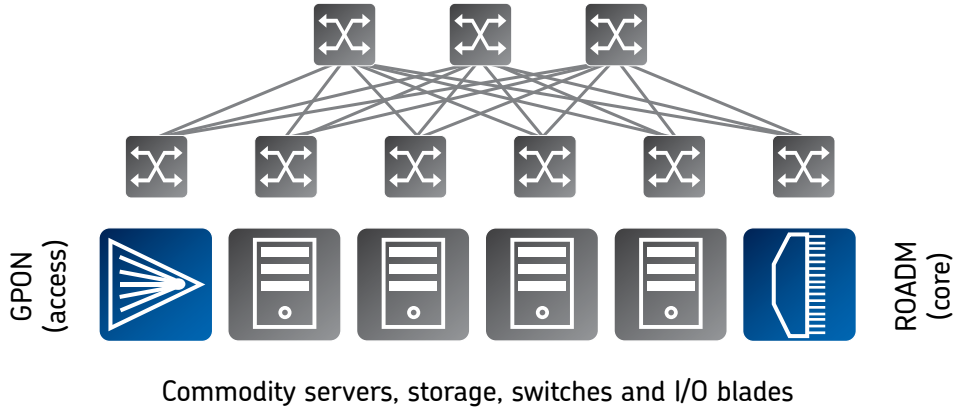
Open software architecture

Data center resources are controlled by specialized software-defined management applications assigning available resources to hosted virtual applications. With our FSP Network Hypervisor, you can now take complete control of the optical transport capacity and manage your DCI network as an integral part of your CORD environment. In order to effectively deal with the analogue nature of optical signals, our FSP Network Hypervisor automatically handles all the limitations of optical transmission and provides transport services control for optical network orchestration.

Multi-layer SDN control

IP packet network and the underlying optical transport network are generally decoupled in current network architectures. They are planned, designed and operated separately by different teams, leading to significant inefficiencies. The forward-looking design of our FSP 3000 optical transport solution helps you to migrate smoothly to the new CORD architecture. Its open hardware and software design is prepared for multi-layer optimization in a CORD environment, based on service availability, economics and your policies. Bandwidth provisioning becomes more agile and much faster, while your network utilization improves dramatically.

> “Reinventing central offices for efficiency and agility”



CORD hardware architecture

Transforming networks with open line systems

Optical transport equipment can look similar. And with increasing standardization of technology, you could be excused for thinking they are all pretty much the same. However, you need to be aware of other architectures that can have serious long-term ramifications for your business. With disaggregation, each layer of your transport network can evolve independently and be independently optimized for performance and cost. It prevents vendor lock-in by disaggregating the photonic layer from the terminal layer. Open source software and hardware collaborations such as the Facebook-sponsored Telecom Infra Project are supporting this approach.

Innovation through disaggregation

The photonic layer provided by our FSP 3000 CloudConnect™ OLS constitutes the core of your transport network and supports functions such as wavelength multiplexing, wavelength switching, amplification, gain equalization and fiber impairment compensation. The terminal layer sits hierarchically above the photonic layer and is where transmission modulation formats are assigned. With disaggregation, wavelengths can originate from any DWDM-compliant transmission and routing equipment. It no longer prevents you from taking advantage of different technology lifecycles, which are typically five to seven years for the OLS and two to three years for the terminal layer.

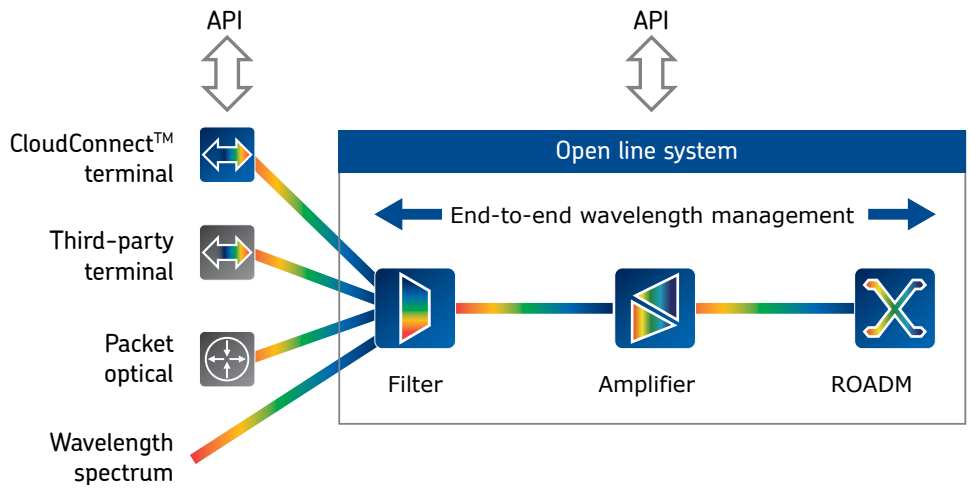
Open and programmable software architecture

Standardized modeling of network elements is the ultimate goal to provide fully interoperable programmable network functions. The drive for open optical architectures also means a move away from closed, per-vendor, per-product management and control systems. With native support for YANG modeling, NETCONF/RESTCONF protocols and open APIs, the OLS of our FSP 3000 CloudConnect™ can be consistently managed and controlled, thus minimizing your OPEX. Common, open and programmatic northbound interfaces and protocols abstract your network, enabling control by third-party SDN applications, creating a unified networking view and speeding up integration. They are a mandatory component when operating OLSs in your network infrastructure.

> “Driving open and disaggregated packet-optical transport”

Benefits of open line systems

1. Investment protection by network disaggregation
2. Each layer can evolve independently and be optimized for performance and cost
3. Standardized modeling of network elements and transceivers
4. Significant savings via footprint and power efficiencies
5. Open to lease spectrum to anyone with any terminal equipment



Disaggregation of the open line system

Elasticity and automation through SDN control

By extending SDN to the optical transport layer, resources of your optical network are virtualized and can be controlled along with switching, routing, storage and compute resources available in your network and data center. Virtualization and SDN control allow all resources to be dynamically allocated under the supervision of a centralized control system. Centralized orchestration of all resources is the prerequisite for optimized end-to-end, multi-layer data flows in your cloud-centric network. New connections can be brought up and torn down again in less than a minute, automatically or at the push of a button.

Openness calls for network abstraction

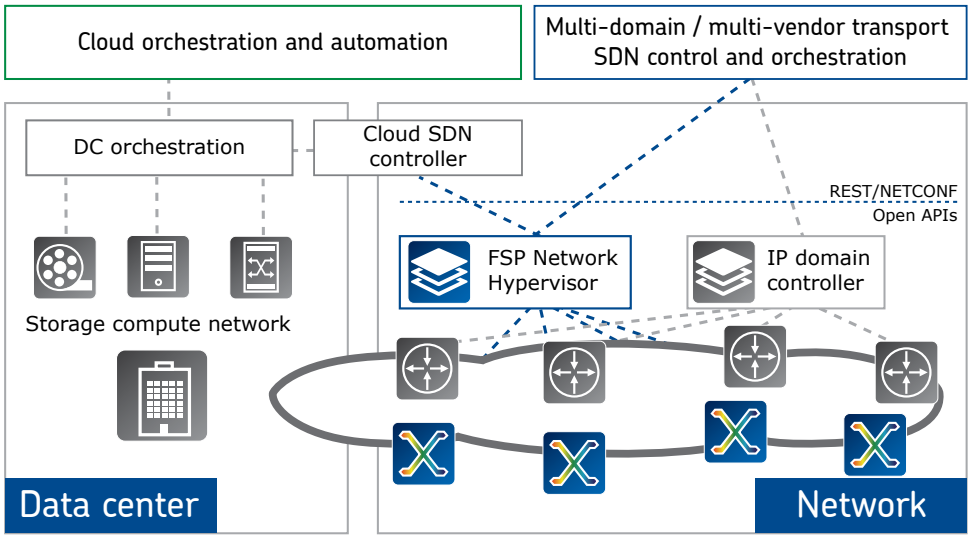
Optical network virtualization and integration into open control architectures can be achieved in many different ways. Some scale and are easy to implement, others don't. When it comes to virtualizing your optical network and its resources, our FSP Network Hypervisor becomes a core component. It provides an abstraction layer for the network hardware and allows your network engineers to create virtual networks that are completely decoupled and independent from your underlying physical infrastructure.

By hiding the complexity and intrinsic physical characteristics of the underlying network infrastructure, our FSP Network Hypervisor enables segments of a virtual network to be controlled independently and provisioned dynamically. A hierarchically structured SDN control architecture is the only way to reduce complexity and enable scalability at the SDN control layer above. And if you are looking for a truly open architecture, building your orchestration on top of our FSP Network Hypervisor is the only alternative.

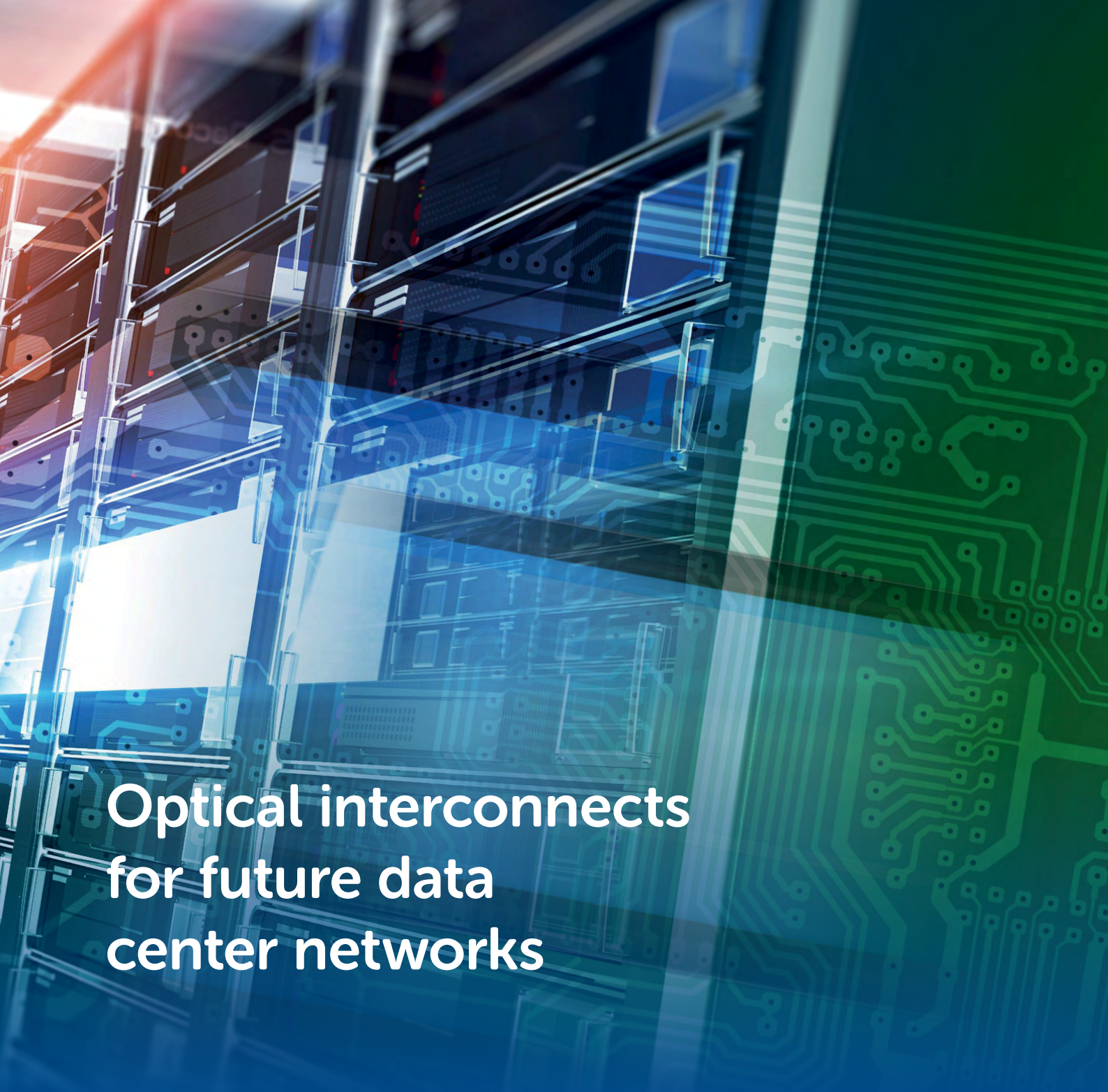
The FSP Network Hypervisor

1. **Hiding complexity:**
   Presents an abstracted view of the FSP 3000 optical transport network, off-loading the centralized SDN controller
2. **Smooth network transformation:**
   Enables combination of traditional operational processes with fully automated, open control of the optical layer
3. **Proven solution:**
   Successfully deployed in various proof-of-concept installations in combination with commercial orchestrators and SDN controllers

> "Orchestrating and programming multi-domain optical networks"



SDN cloud architecture



Optical interconnects for future data center networks

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About ADVA Optical Networking

ADVA Optical Networking is a company founded on innovation and driven to help our customers succeed. For over two decades our technology has empowered networks across the globe. We're continually developing breakthrough hardware and software that leads the networking industry and creates new business opportunities. It's these open connectivity solutions that enable our customers to deliver the cloud and mobile services that are vital to today's society and for imagining new tomorrows. Together, we're building a truly connected and sustainable future. For more information on how we can help you, please visit us at: www.advaoptical.com.

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