

Infinera Transcend Controller Solution

Open, Programmable, and Automated for On-demand, Application-centric Service Agility

TRANSFORMING NETWORK ARCHITECTURE

Network operators face new challenges due to a fundamental transformation in network architectures, technologies, and business models. Video and other traffic generated from cloud-based applications and online services, such as cloud storage, IPTV, and music downloads, create significant and agile traffic patterns in mobile and fixed networks. Network operators are driven by ever-increasing quality expectations from end customers and the need to boost flat or even decreasing revenue. In addition, technology trends, including network function virtualization (NFV) of Layer 4+ functions, new data center architectures and applications, ultra-flexible high-capacity optical networks, and mobile network evolution to LTE-A/5G, create new requirements and fundamental changes in network architectures.

While technology to develop a fully flexible, ultra-high-capacity optical network layer allows cost-efficient traffic switching on the lowest layer of the network, an open, programmable, and automated software platform is required on top of the physical network to support efficient service creation and agile service reconfiguration. This software platform must support the rapid development of innovative applications and corresponding business models. The Infinera Transcend SDN Solution gives network operators a powerful toolkit to drive down network costs and address the operational challenges of the competitive carrier environment.

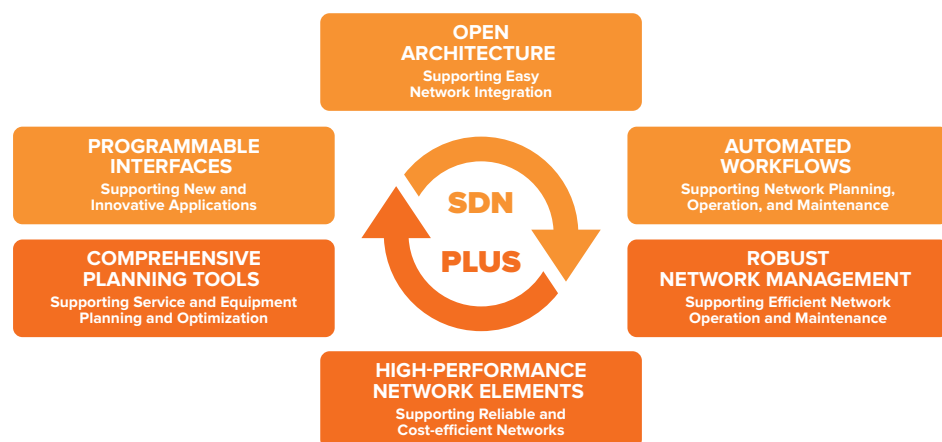


Figure 1: Open, programmable, and automated software platform for agile network control

BENEFITS OF THE INFINERA TRANSCEND CONTROLLER SOLUTION

- **Real-time SDN programmability and automation** unleash new, efficient, and innovative applications
- **Open and standards-based controller interfaces** give full application control of network services
- **Intent-based end-to-end service provisioning** ensures service delivery in the most efficient network configuration
- **Automatic multi-layer optimization** offers the best network reliability at the lowest network cost
- **Network virtualization and slicing** enable multi-tenancy for cost-efficient, multi-purpose networks
- **Orchestrator-agnostic design** provides easy integration into customer-defined environments

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INFINERA TRANSCEND CONTROLLER DESIGN PRINCIPLES

The Infinera Transcend Controller is a modular SDN software solution that combines the benefits of an open, programmable, and automated multi-layer SDN software platform with a proven portfolio of packet optical transport and IP/MPLS edge routing solutions to enable dynamic end-to-end network control. The Infinera Transcend Controller provides operators the tools to address the operational challenges of unpredictable and agile traffic loads and to differentiate from the competition with innovative services.

To unleash the capabilities of SDN-based network control, the Infinera Transcend Controller leverages the following design principles:

Openness

The goal of an open architecture is to create a focused multi-vendor solution with network management integration. This solution includes:

- **Open/standardized interfaces** – This feature exposes and unifies network functions of the control layer toward higher-layer management to support smooth and efficient network integration.
- **Orchestrator-agnostic architecture** – This open SDN-based architecture reduces integration efforts for network control and gives network operators several options to implement network orchestration and applications on top of SDN controllers. The orchestrator can be customer-specific and based on open source projects such as OpenDaylight, ONOS, or a commercially available implementation. The design goal of the Infinera Transcend Controller is to support an orchestrator-agnostic architecture by:
 - **Pre-integration with open source or commercial orchestrators** to speed up timelines for integration projects and reduce integration efforts.
 - **Support for orchestrator integration** into customer-specific OSS/BSS architectures to adapt to predefined environments, use cases, and workflows.
- **Multi-vendor focus** – Since most key use cases require multi-vendor support, the Infinera Transcend SDN Solution is designed to support end-to-end service control over multiple layers, technologies, and vendors.

Programmability

Opening up the network for programmability is the precondition for network automation and innovative applications. To optimize the solution for enhanced programmability, the architecture must support the following concepts:

- **A high level of network abstraction** is necessary to hide the complexity of the physical network and to unify and simplify the interfaces (including NBI and east/west interfaces). A high level of abstraction releases higher-layer controllers from managing technology or vendor-specific details of the network and helps the higher-layer controllers support high-performance applications, even for large-scale networks.
- **Intent-based service control** is a key concept to reach network abstraction and implement an end user- and application-centric view of the network. Services are simply defined by endpoints and a set of service level agreement (SLA) parameters (e.g., latency, resilience, or restoration parameters). The Transcend Controller creates and monitors the services according to the defined SLA while ensuring cost-efficient resource assignment. Network events and alarms are mapped to an abstracted service status (e.g., up, down, impaired). The higher-layer controllers are notified of this status to hide technology-dependent alarms and network details and to simplify application programming.
- **Path computation element (PCE)** is another concept to abstract and simplify the network. The PCE interface provides enhanced routing functionality through a simplified interface and hides the complexity of the underlying network technology (e.g., optical impairments and fiber-dependent reach) to ensure simple application programming. The routing request can be performed by the PCE in three different modes: calculating the path only while not touching the network, calculating the path and reserving resources for a determined amount of time, and routing and switching the path immediately.
- **Network virtualization and slicing** are used to assign network resources to different network domains with access rights for specific user groups or applications, thus enabling multi-tenancy for a cost-efficient implementation of real multi-purpose networks.
- **REST/YANG-based interfaces** are in line with the latest software technologies and facilitate integration between systems. The technology allows the exchange of interface information models and provides the ability for applications to easily adapt to changed models by loading the YANG model in runtime.
- **Exposure of network primitives** occurs when the Transcend Controller provides network primitives on request of the higher-layer controllers and applications. The parameters could be the network's physical topology or service-related parameters. This process allows the application to request detailed network parameters, even in an abstracted network.

Automation

Automation is a precondition to reach OpEx and CapEx optimization in large-scale and highly agile networks. This design principle includes:

- **Integration of the controller with Transcend Network Management System (Transcend NMS) and planning tools** – Basically, there are two areas of workflow optimization:
 1. **Optimization of planning, commissioning, and operational workflows** helps customers, particularly those with a greenfield network, to implement and efficiently architect the network.
 2. **Reoptimization and maintenance workflows** enable customers to maintain optimized network resource assignment and solve the issue of service defragmentation, which can occur with the installation of new links and rerouting of services during maintenance work.

Infinera has significant and proven experience with highly automated and optimized planning, installation, operations, and maintenance workflows in large-scale mobile and optical networks.

- **Automatic restoration/routing schemes** – These schemes define an application-based reaction to a network event, including fiber breaks, network congestion as a result of changes in user behavior, or any other disasters. Automation enables operators to implement a reliable network with efficient use of network resources by minimizing OpEx.
- **Multi-layer optimized service management** – A specific example of network automation is the exchange of information between the controller's modules on an east/west interface, or more specifically, the multi-layer optimization between IP/MPLS and packet optical services. Infinera has implemented an east/west interface between the Transcend Controller solution module supporting packet technologies and the module supporting transport technologies. This concept allows the pre-integration of both solutions, independent of the customer's choice of orchestration solution. The interface pushes transport network service topology and related information, such as service latency, Shared Risk Link Group (SRLG), and resilience, as well as service status, toward the Transcend Controller to allow multi-layer-optimized and transport layer-aware service routing. This enhances service reliability with the awareness of the shared risks of transport services. To provide pre-integration of controllers between multiple vendors, Infinera has also implemented an IETF-standard east/west RESTCONF interface.

INFINERA TRANSCEND CONTROLLER ARCHITECTURE

The Infinera Transcend Controller is a modular SDN software solution that provides highly flexible and adaptable configurations for customer-specific networks and workflows. The modular design supports easy and flexible integration with other solution components from Infinera, customer-specific software parts, or software from other vendors.

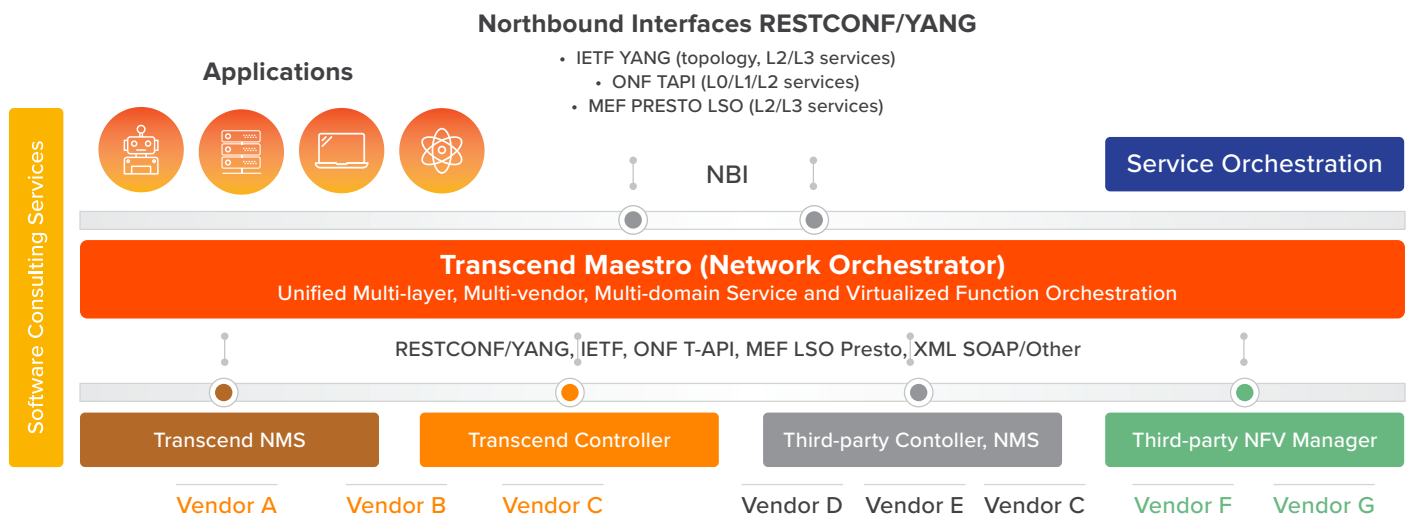


Figure 2: Infinera Transcend Software Suite - modular design to support easy and flexible integration

The Infinera Transcend Controller

One of the basic concepts in SDN architecture is shifting control functions from the network to a centralized controller. This concept enables new network functionality, such as new routing or specific service restoration behavior, without touching the physical network elements, and it creates new requirements for the reliability and performance of the central controller. SDN controllers cover the most complex functionality as they abstract and virtualize the network. The Transcend Controller shields the technical complexity and vendor-specific behavior of the physical network toward the higher-layer controllers and provides functions to control the network. These functions include:

- **Path computation elements** provide support for simplified routing functionality. The PCE shields routing-related network complexity toward the higher-layer controller, including, for example, the calculation of optical impairments on the physical fiber.
- **Service restoration** allows the Transcend Controller to provide specific restoration schemes, such as rerouting services, in combination with service protection. For higher-layer controllers, using parameters in the corresponding interface, the Transcend Controller manages all service configurations and supervision.
- **Planning support** in conjunction with the Transcend NMS and planning tools enables the virtual introduction of new nodes or cards, including those nodes visible to the higher-layer controllers and application.

Infinera Transcend Controller – Transport Support

The Infinera Transcend Controller's support for transport networks spans different transport layer technologies, such as optical DWDM layers, electrical ODU switching layers, and Carrier Ethernet (CE)- and MPLS-TP-based packet layers, to provide end-to-end service control. The controller enables SDN-based service control for Infinera's optical and packet optical transport portfolio. The controller offers an open and OIF standard-based REST NBI to provide real-time, programmable multi-layer control to higher-layer controllers. The controller also supports a RESTCONF/YANG-based topology and service APIs according to the IETF standard for east/west interfaces with other SDN controllers on the same control layer.

Besides the abstraction and virtualization functions, SLA control is one of the key features that enables applications to be network aware. A higher-layer controller and applications can establish services with abstracted parameters such as endpoints and SLA parameters (e.g., bandwidth, latency, resilience schemes). The controller ensures the SLA during routing and service configuration using the most cost-effective implementation. The Transcend Controller supervises the service according to defined SLA parameters during the service lifetime. In case of network events, the controller takes action, for example, by rerouting to put the service in line with the SLA or by informing the higher-layer controllers about the new service status. The service status is generated by mapping technology and vendor-specific alarms and network conditions. This service status (e.g., up, down, or impaired) is an abstracted parameter suitable for end users. As a centralized platform, the Infinera Transcend Controller supports reliability and scalability features for the latest carrier-grade software technologies.

Infinera Transcend Controller – Packet Support

The Infinera Transcend Controller supports SDN-based service control on the IP/MPLS layer – currently supported packet devices include Infinera DRX Series, Infinera 8600 and 8800 Smart Routers, Infinera 7090 CE Packet Transport Platform, Infinera 6300 Series, and Infinera 8100 Managed Access System. The controller supports a built-in PCE to deliver cost-effective routes that meet SLA parameters across multiple layers and technologies. In addition, the Transcend Controller supports a multi-domain network view to work as a second-layer hierarchical SDN controller below the orchestration layer. The Transcend Controller has an open REST-based interface to integrate with higher-layer controllers and supports an east/west REST-based interface that works to support the routing of transport layer-aware LSPs. Via this east/west interface, the Transcend Controller can upload the underlying transport service topology as well as service-related parameters, including bandwidth, SRLG information, and latency. As an example, the Transcend Controller considers the SRLG information during LSP routing and selects an optical path for the protected LSP that does not share the same risk. In case of a fiber break, only the protection or working path is affected and not the client traffic. Consequently, the Transcend Controller can reroute the affected LSP so that the service is protected again. This functionality allows efficient protection of services against multiple network failures if they should occur at the same time.

SDN USE CASES

The Infinera Transcend Controller enables the development of new applications and services – and the ability to bring these new revenue-generating opportunities to market quickly. The solution uses the real-time programming capabilities of SDN to control, monitor, and react to dynamic network changes, while implementing a broad set of use cases for fixed and mobile networks and data centers.

- **Bandwidth on demand**
- **Multi-layer optimization of IP over transport services**
- **Service and network defragmentation**
- **Performance- and application-aware services**
- **Network slicing**
- **Service restoration**
- **SLA-based service assurance**
- **Dynamic bandwidth control**
- **Event-based network responses**
- **NFV controller interworking**

For more detailed information about SDN use cases for fixed and mobile networks, visit www.infinera.com.

Transcend NMS

The Infinera Transcend NMS supports end-to-end multi-layer network management functionality (FCAPS) for Layer 0-3 network operation and maintenance workflows. The Transcend NMS also supports network technologies such as DWDM, OTN, MPLS-TP, Ethernet, and IP/MPLS. To optimize all workflows from network planning, installation, operations, and maintenance, Infinera integrates the Transcend NMS with the Transcend Controller and planning tools. A service that is provisioned through a portal application in the SDN architecture automatically displays in the Transcend NMS for supervision and maintenance. This workflow integration enables not only reduced OpEx but also optimized CapEx.

Planning and Optimization

Infinera supports customers with specialized planning tools for greenfield planning and network reoptimization. Planning support is also integrated into the Transcend NMS and Transcend Controller. For greenfield and network extension planning, the key tasks of the planning tools are equipment planning and generating material lists. The tools support the network configuration of physical network elements based on planning data via file transfer or scripting, and transfer information, including topology, equipment, latency, and optical performance, to the Transcend NMS and Controller. For network reoptimization, the planning tools support functions to upload the current network status and to optimize service grooming, aggregation, and multi-layer resilience, as well as support for the analysis of capacity growth scenarios.

Orchestration and Applications

The orchestration strategy and applications are customer-specific to the physical network architecture, technologies, customer workflows, and the financial, strategic, and R&D capabilities of the operator. Typically, an operator selects one of the following orchestration strategies:

- Commercially available orchestration solution, e.g., Infinera Transcend Maestro or another vendor's
- Professional services-based orchestrator development
- Operator in-house orchestrator development based on open source
- Operator in-house development based on existing OSS/BSS, planning, or other systems

Infinera's SDN solution is orchestrator-agnostic not only by implementing standards-based interfaces but also by pre-integration with open source or commercial orchestrators. This pre-integration speeds the timelines for SDN integration projects and reduces integration effort. In addition, the Infinera Transcend Controller can integrate with customer-specific orchestrators and OSS/BSS architectures to adapt to specific use cases and workflows.

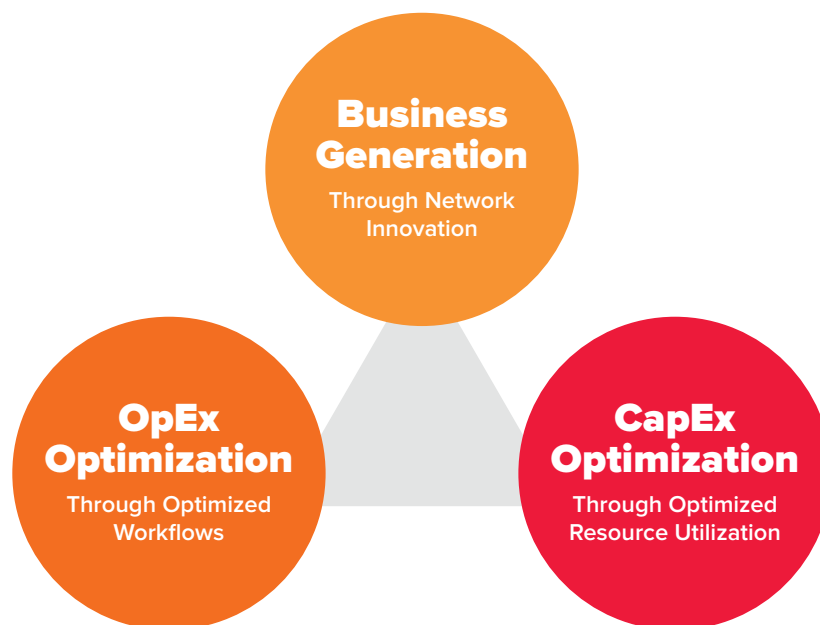


Figure 3: SDN business value

GENERATING VALUE AND NEW BUSINESS THROUGH SDN-ENABLED CONTROL ARCHITECTURES

The value of an SDN-enabled network depends on the implemented use case, the purpose of the network, and the workflows of the service provider. According to customer feedback and analyst assessments, simplified service provisioning, automation, and network control are key drivers for SDN.

- **OpEx optimization** – reduced effort for network control
 - Automated end-to-end service provisioning
 - Automated multi-layer service management
 - Fast and easy network/service reconfiguration
 - Automated resilience schemes
 - Integrated workflows for planning, installation, maintenance, and optimization
- **CapEx optimization** – optimized resource usage
 - Resource status-aware reuse of equipment
 - Optimized multi-layer resource usage
 - Multi-purpose networks through network virtualization – share the network between several different users/departments
 - More efficient network utilization through real-time load balancing/restoration
 - Integration effort savings through smarter interfaces and architectures
- **Business generation** – driving new business generation through network innovation
 - Enhanced quality of experience for end users by:
 - Portal-based services creation
 - Self-optimizing networks, (e.g., automatic rerouting through network congestion)
 - Self-healing networks, (e.g., application-based service restoration)
 - Enhanced speed of business through end-to-end, multi-layer service creation
 - Fast introduction of innovative services