

Infinera IP/MPLS and IP-Optical MBH and FMC Solution

Innovative Smart Router Platforms

ADDRESSING THE CHALLENGES OF MOBILE AND FIXED MOBILE CONVERGED NETWORKS

Network operators are facing formidable challenges in mobile and fixed network environments. Besides the ongoing, ever-increasing demand for transport capacity in all network domains (access, aggregation, and core), network capabilities must be extended with new functionalities for the wide variety of available services. For example, mobile and fixed transport networks must continually address the challenge of streaming real-time services, which dominate overall data volumes in networks worldwide. In addition, video services are extremely bandwidth intensive, sensitive to packet loss, and require minimal delay variation.

Mobile backhaul architectures in particular face additional challenges with new mobile network standards. LTE, LTE-A, and emerging 5G services require extremely low latency (in the range of 20 ms to 1 ms) and high accuracy phase and time-of-day synchronization demands. Mobile networks will continue the architectural evolution toward a heterogeneous cell infrastructure (femtocell, microcell, and macrocells) and a parallel coexistence of several radio technologies. This trend will require extreme flexibility and modularity in the transport domain to address site requirements including high capacity and cost efficiency.

Enterprise, business, and residential applications require reliable and flexible service availability for new service characteristics such as real-time communication and the appropriate allocation of resources. In addition, support of legacy network infrastructure and services is another important requirement for packet-based transport networks.

Fixed and wireless convergence is happening in the service layer and in underlying infrastructure networks. The distinction between these previously separate applications is now becoming blurred, and operators are looking for transport network solutions that can address all types of services.

OFFERING FLEXIBLE AND SCALABLE MULTISERVICE TRANSPORT NETWORK SOLUTIONS

The 8600 Smart Router Series offers highly flexible, efficient, and low cost solutions for carrier transport networks. The 8600 Series provides robust and compelling end-to-end IP/MPLS capabilities for fixed and mobile networks. The modular architecture and advanced integrated functionalities of the 8600 Series meet all of the requirements for today's transport networks and ensure future-proof capabilities for wireline, wireless, and converged network scenarios. For mobile backhaul applications, the 8600 Series delivers an advanced multi-technology transport solution for LTE, LTE Advanced, and 5G in the future, as well as for legacy mobile standards such as GSM and WCDMA.

BENEFITS OF THE INFINERA 8600 SMART ROUTERS

- **Offers** lowest power consumption enabling up to 70% reduction in OpEx
- **Provides** highest service provisioning efficiency to configure 80% faster
- **Delivers** leading high performance synchronization for 70% - 80% CapEx reduction
- **Leverages** innovative SDN/NFV Packet Controller for multi-layer, multi-vendor control
- **Combines** IP-Optical transport to increase capacity and enable low latency for LTE, LTE-A, and 5G
- **Features** industry-leading network management through the Infinera Transcend Chorus for Packet network management system

Infinera 8600 Smart Router Portfolio Highlights



Infinera's 8600 Series consists of several router options including the 8665 and 8625 shown above.

The sophisticated, fully integrated, and high performance synchronization features offered through the 8600 Series provide industry-leading flexibility and accuracy for all existing and future mobile generations. It delivers a complete solution on a single transport platform for the support of the various service needs for mobile and fixed networks, including Ethernet and pseudowire multiservice applications. For business services, the 8600 Series provides flexible and scalable transport from Customer Premises Equipment (CPE) to Provider Edge (PE) routers and supports both critical business services and best effort data requirements.

OPTIMIZING TRANSPORT NETWORKS WITH THE 8600 SERIES PORTFOLIO

In combination with the robust management capabilities of the Infinera network management system, Infinera Transcend Chorus for Packet, the 8600 Series provides an optimized, scalable, and versatile solution for multiservice transport networks. Designed to meet demanding requirements such as increasing capacity, ensuring power efficiency, and delivering scalability and flexibility for mobile backhaul and fixed networks, the 8600 Series offers a wide range of platform options for fully integrated, end-to-end solutions spanning core to access, enterprise, and cell site applications. Providing an extensive Ethernet and IP/MPLS feature set, all of the 8600 Smart Routers are LTE and LTE-A ready and prepared for 5G in the future. The 8600 Smart Router portfolio covers solutions from the extremely compact Infinera 8602 Smart Router to the robust 15RU Infinera 8665 Smart Router.

SUPPORTING ALL-IP AND FIXED NETWORKS

The 8600 Series provides an optimal solution for mobile and fixed networks that deploy microwave, wired Ethernet, or dark fiber as the underlying transport media. With support for IP routing as well as MPLS and Ethernet switching tables, the 8600 Series provides the flexibility needed to serve evolving network architectures and applications. The 8600 Series supports a mix of IP and Ethernet services, such as IP VPNs, VPLS and Ethernet pseudowires, and advanced traffic management features with hierarchical QoS support for flexible end-user service definition. For legacy networks and network migration applications, the solution also provides a wide range of TDM, SDH, and ATM interfaces with TDM and ATM pseudowires. IP-Multicast support is available for applications such as eMBMS and IPTV broadcast delivery. Figure 1 illustrates the various network positions for the 8600 Series. The platforms can be deployed in all network domains for various mobile and fixed applications. The 8600 Series is completely integrated into the overall Infinera transport solution portfolio. Seamless IP-Optical integration through Layer 3 offers a transport network solution for cost-efficient bandwidth and optimized cross-layer transport architectures.

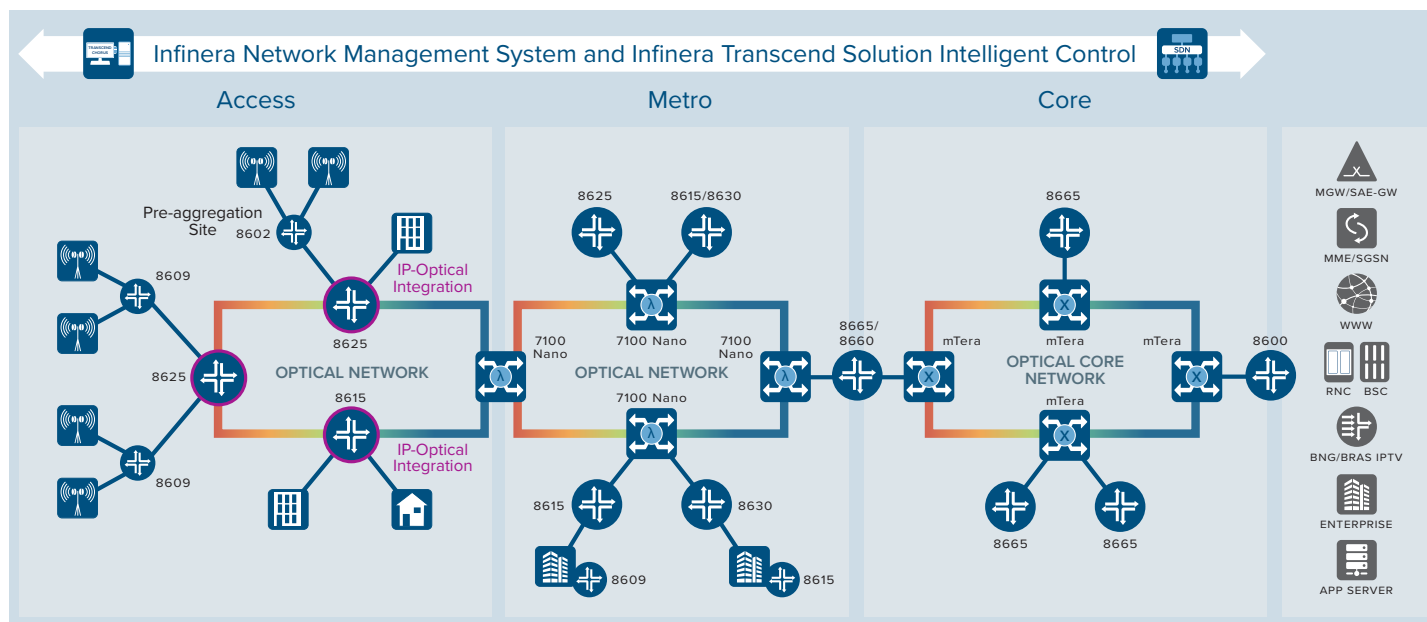


Figure 1: 8600 Smart Router Applications

FEATURING LOWEST POWER CONSUMPTION FOR MINIMIZED OPEX

The 8600 Series is built on an advanced hardware and software design, which provides significantly reduced power consumption. It offers an annual OpEx savings between 50% and 69% per site. With cutting-edge silicon technology, a new generation of high performance components, and intelligent power management controlled per module, the 8600 Series provides industry-leading power efficiency, as shown in Figure 2.

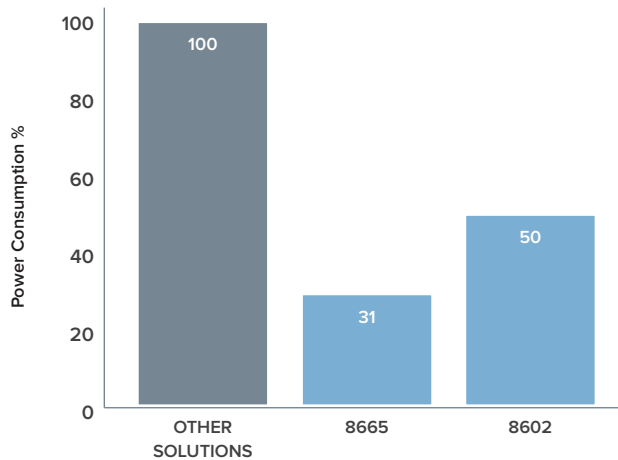


Figure 2: 8600 Smart Router Power Efficiency

LEADING OPERATIONAL AND MANAGEMENT EFFICIENCY WITH INFINERA TRANSCEND CHORUS FOR PACKET

Transcend Chorus for Packet is a single network management system across mobile and business Ethernet platforms. This powerful tool offers service providers full end-to-end support for commissioning, monitoring, and configuring services and troubleshooting. This single, overarching network manager simplifies network management and can improve profitability and competitiveness through operational efficiency. Its advanced graphical user interface (GUI), automated wizards, and plug-and-play features guide users through tasks and shorten service provisioning time. The results are faster time-to-revenue and a reduction in operational expenses. Transcend Chorus is designed to meet current operational challenges and address future transport network requirements through:

- **Simplified scalability with network expansions** – Flexible architecture that scales with network growth while deployment tools enable a fully automated deployment, e.g., for upcoming small cell deployments
- **Manage network availability to maximize QoE** – Accurate provisioning of real-time and historical information along with purpose-built troubleshooting and service assurance tools to guarantee and verify SLA
- **Flexible service management** – Intelligent workflows for a scheduled or immediate update of network and service parameters one by one or in a batch, including built-in checks to verify correct configurations
- **Automated network documentation** – One centralized database storage for all network element data
- **Built-in automation platform for customizing operator workflows** – The operator can use the platform directly or request access by Infinera professional services for building new network management tools and automating frequent or error-prone tasks
- **Multi-vendor management with generic node integration functionality** – Generic plug-and-play integration of third-party network elements with modeling, alarm management, performance monitoring, and service monitoring

8600 SMART ROUTER PORTFOLIO



8602



8603



8609



8611



8615



8625



8630



8660



8665

PROVIDING A FULLY INTEGRATED SYNCHRONIZATION FEATURE SET

Reliable and precise synchronized networks are essential for accurate service provisioning to meet the individual requirements of various applications such as gaming, financial trading, data center connectivity, or in LTE, LTE-A, and future 5G mobile networks. In order to meet these requirements for current and future transport networks, the 8600 Series is equipped with a fully integrated set of synchronization features that guarantee high robustness, accuracy, and performance synchronization processing, as illustrated in Figure 3.

The full set of synchronization features are completely managed by Transcend Chorus, including the Global Navigation Satellite System (GNSS) solution. The accuracy of the synchronization signal is verifiable on each managed network element. It provides efficient solutions to realize frequency and/or phase synchronization in packet-based transport networks. Each platform in the 8600 Series supports IEEE 1588v2 (Telecom-Boundary Clock, Telecom-Grand Master and Telecom-Slave Clock) and Synchronous Ethernet for packet-based synchronization. It provides the most cost-efficient, future-proof synchronization solution available in the industry. For example, with the integrated T-BC (Telecom Boundary Clock) and T-TSC (Telecom Time Slave Clock), the 8600 Series provides CapEx savings of up to 87%. Furthermore, it reduces OpEx with power savings of up to 74% per node compared with external synchronization solutions, as shown in Figure 4.

In addition, the 8600 Series offers a unique, compact, and cost-effective solution for GPS-based synchronization. Traditional GPS solutions are more complex and require significant investments per site. The Infinera Integrated GPS (GNSS) SFP Module in the 8600 Series addresses these challenges through its GPS receiver functionality. As the most cost-efficient, most compact, and most flexible GNSS synchronization solution in the market, the 8600 Series provides this Integrated GPS (GNSS) SFP Module, which also supports GLONASS and can be installed at all sites where satellite-based timing is required. Figure 5 shows the cost advantage of the Infinera solution, which minimizes the Total Cost of Ownership (TCO), including the reduction of CapEx by 72% and OpEx by 75%.

Infinera 8600 Provides Fully Integrated Features for Synchronization of Today's and Future Mobile Networks

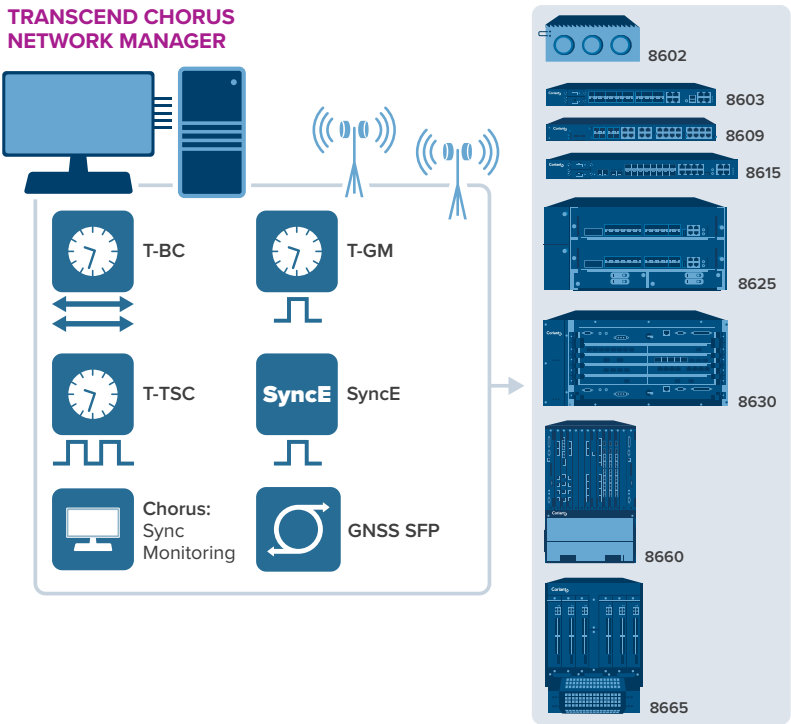


Figure 3: 8600 Smart Routers provide a fully integrated synchronization feature set

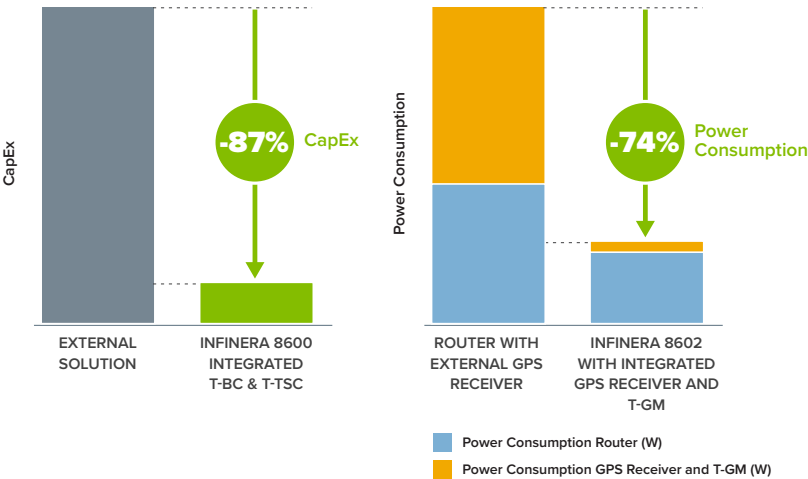


Figure 4: Lowest CapEx and OpEx with fully integrated synchronization functionalities

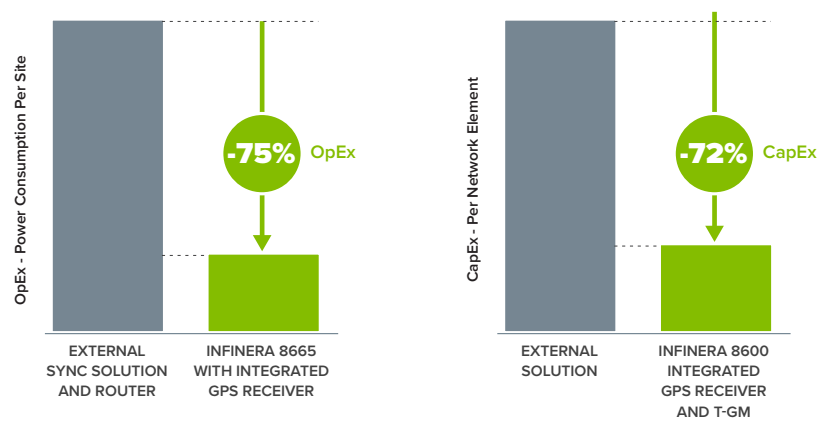


Figure 5: Minimum TCO with integrated compact GNSS solution

DELIVERING HIGH PERFORMANCE SYNCHRONIZATION DATA PROCESSING

As high precision synchronization of transport networks is becoming a critical and challenging requirement in all types of transport networks, Infinera provides unmatched high performance synchronization processing on the 8600 Series. This highly sophisticated implementation provides the following unique advantages for transport networks:

- Maximum synchronization accuracy across the entire network
- Highest robustness in challenging network conditions

Recent mobile standards require phase synchronization with a maximum time error of $+1.5 \mu\text{s}$ for LTE-TDD and LTE-A. This timing relates to the end-to-end error budget for the complete transmission path of the PTP packets from the T-GM through the transport network to the base station. The different network instances or network elements have a certain time error budget available that is allowed to be consumed by each network instance. The ITU-T G.8273.2 and ITU-T G.8271.1 recommendations describe the maximum time error budget of 100 ns per T-BC, T-TSC, and T-GM. Within the overall budget of $1.5 \mu\text{s}$, each synchronization instance is allowed a maximum absolute time error of 100 ns. Therefore, the maximum time error of an end-to-end synchronization path is an important indicator of the quality and the robustness of a mobile transport network.

With upcoming 5G mobile network technology, synchronization requirements are expected to be three times stricter than in LTE-TDD and LTE-A networks. The maximum time error will be reduced to $0.51 \mu\text{s}$, which will lead to a further reduction in the allowed maximum time error budget per network element based on the ITU-T recommendation. In order to meet these future synchronization challenges, the 8600 Series provides extremely high performance synchronization data processing and extremely low time error. As depicted in Figure 6, the 8600 Series network elements consume only between 15% and 26% of the maximum allowed time error as recommended by the ITU-T standard. This low percentage range strongly differentiates the 8600 Series and ensures reliable phase synchronization in current and future mobile networks.

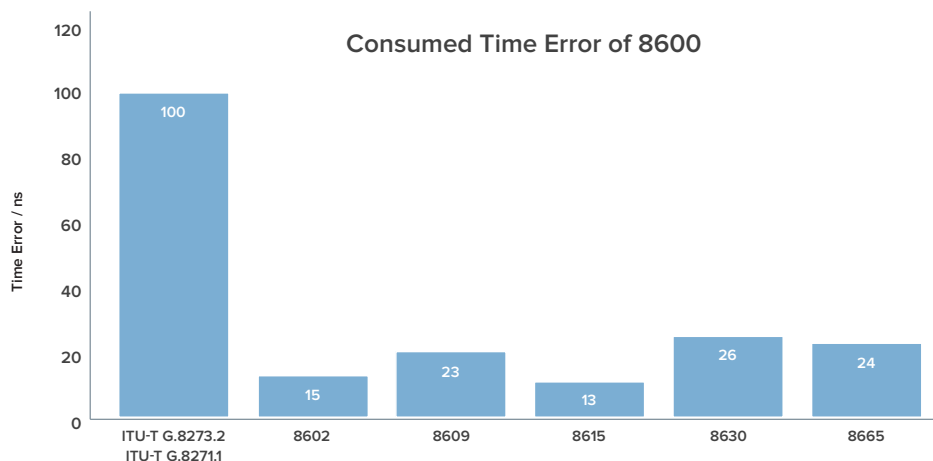


Figure 6: 8600 Smart Router High Performance Synchronization Data Processing

ENABLING NETWORK SLICING AND NETWORK VIRTUALIZATION WITH THE INFINERA TRANSCEND SOLUTION

With the evolution of users accessing devices and the application environment in transport networks, carrier networks are faced with the challenge of providing more agile service availability and adaptability. Mobile network domains are a major service agility driver where various application characteristics dependent on user mobility and location must be managed. Current networks are based mainly on a hardware-centric architecture where bandwidth is mostly statically allocated. Next-generation carrier networks require a new design and new functionalities in order to become virtual and agile transport networks. Instead of static configured networks for dedicated service scenarios such as mobile backhauling or enterprise services, network slicing offers more options to address numerous application types in the same network. With the Infinera Transcend Solution, Infinera combines SDN and NFV technology offering the opportunity for network segmentation to serve applications such as enterprise services or IPTV scenarios at the same time. This solution increases the service performance of the network and reduces service activation times. The advantages provided with the Transcend Solution are:

- Network virtualization
- Network slicing
- Multi-layer/technology management
- Connection and service visibility
- Connection security
- Network automation
- Bandwidth flexibility

The Infinera multi-vendor SDN controller, Infinera Transcend Symphony for Packet, fully supports the complete 8600 Series. Transcend Symphony is an integral component of the overall Infinera Transcend Software Suite, a modular SDN software suite that combines the benefits of open, programmable, and automated multi-layer SDN architecture and a proven portfolio of IP/MPLS edge routing and packet optical transport solutions to enable dynamic, end-to-end network control and optimization.

LEVERAGING CONVERGED IP-OPTICAL TRANSPORT

The highest transport network expense is providing additional bandwidth for new technologies and applications. Another cost is the high performance transport infrastructure for new applications, including Data Center Interconnect and mobile technologies such as LTE-A and 5G. These applications demand not only more capacity but also require ultra-low latency data transport in the range of 1 ms. These new application environments require a redesign of carrier networks, including intelligent optimization of the flow of data streams between network elements as well as between the network domains.

The 8600 Series provides various expansion options for a future-proof, innovative, multi-layer platform architecture that combines Layer 3 to Layer 0 transport. The 8600 platforms offer solutions that combine colored interfaces on the Smart Routers coupled with the Infinera Pluggable Optical Layer (refer to an example with the Infinera 8625 Smart Router in Figure 7) or the Infinera Groove G30 Network Disaggregation Platform (NDP) (refer to an example with the 8665 Smart Router in Figure 8) as a high-capacity transport underlay. The solution includes colored interfaces on the 8600 Smart Routers coupled with the passive optical transport components of the Pluggable Optical Layer or Groove G30 fully disaggregated optical transport platform as a high-capacity transport underlay. Together with the use of the CFP2 DCO and QSFP28 optical pluggable transceivers on the 8665 and 8625 line cards, flexible IP-Optical multi-layer transport configurations are supported. The passive IP-Optical solution, as shown in Figure 7, is a typical configuration providing cost-efficient multi-layer transport for access networks. Whereas, Figure 8 shows the IP-Optical transport solution based on the Groove G30, which adds an optical transport layer for regional, metro, and long-haul applications. This architecture leverages the flexibility of Layer 3 with cost-efficient optical transport to optimize routing capacity by off-loading pass-through transit traffic to 10/100G optical transport circuits in a low cost and low latency network design. Integrated IP-Optical transport delivers a dramatic capacity increase for routing sites.

Due to the bandwidth boom, the necessity for 10G interfaces is becoming increasingly important in access networks, and carrier networks are planning for 100G interfaces in the future. Therefore, Infinera extends the existing 8600 Series portfolio with the availability of the Infinera 8625 Smart Router. The design of the 8625 Smart Router addresses current and future transport requirements with the flexibility to configure 10G and 100G ports. In combination with optical transport based on the Pluggable Optical Layer, the 8625 Smart Router can easily enable the building of optical rings in the access domain for cost-efficient grooming and optimization. Furthermore, the 8625 Smart Router offers the ability to leverage existing fiber infrastructure more efficiently by multiplying bandwidth.

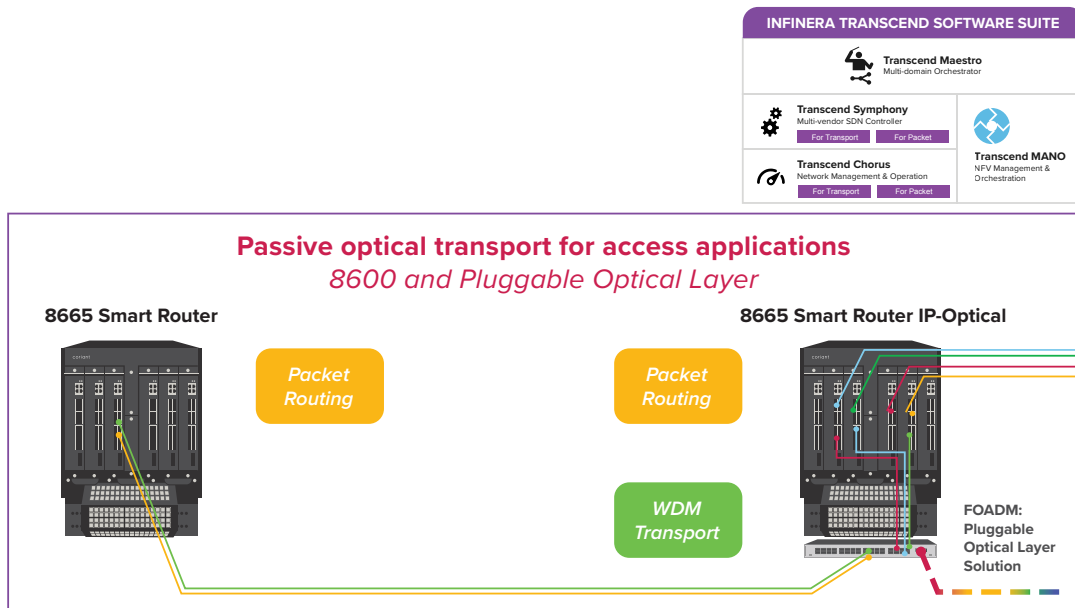


Figure 7: Infinera 8625 Smart Router Variants with the Passive Pluggable Optical Layer Transport Option

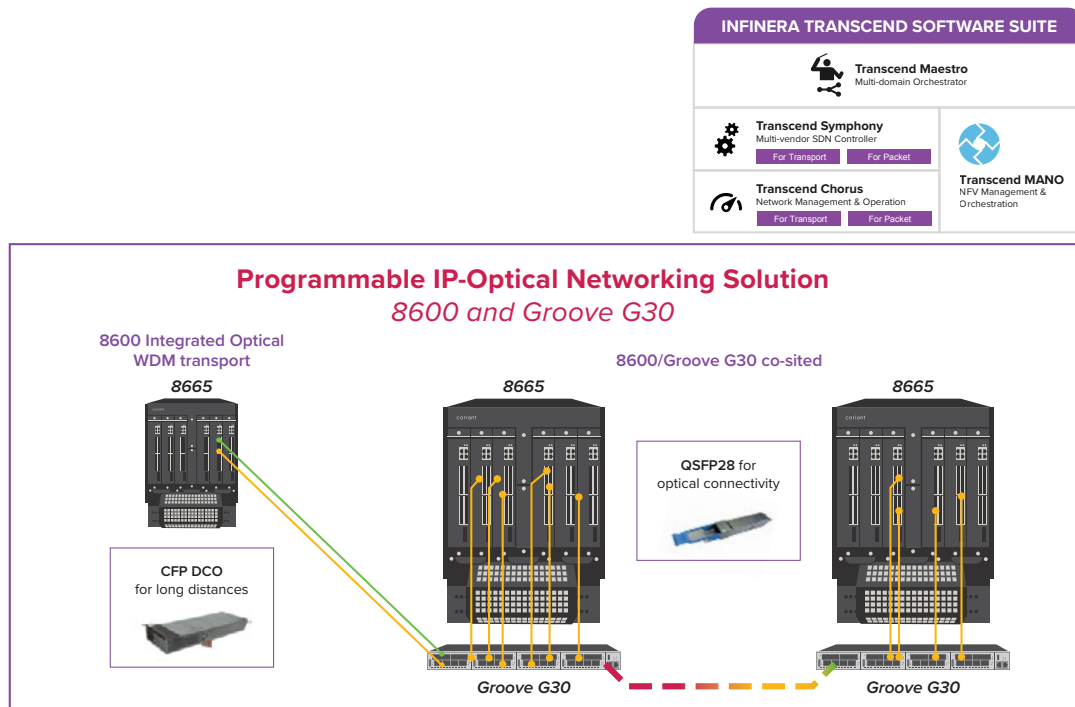


Figure 8: Infinera Smart Router Variants with the Groove G30

The 8600 Series helps mobile and carrier network operators cost efficiently build and scale low latency, high-capacity LTE and LTE-A transport networks. Infinera combines the proven IP/MPLS routing capabilities of the 8600 Series with optical layer capabilities to deliver an enhanced multi-layer solution designed to meet the key challenges of LTE, LTE-A, and 5G in the future. The IP-Optical solution is built on the integrated Pluggable Optical Layer solution on the 8600 Series. For a flexible rollout and a simplified installation of optical transport in all network domains, the integrated Pluggable Optical Layer is supported on the 8665 Smart Router, 8660 Smart Router, 8630 Smart Router, 8625 Smart Router, 8615 Smart Router, and 8603 Smart Router. Figure 9 shows a network example of the efficient use of optical transport, based on the Pluggable Optical Layer solution, combined with IP/MPLS transport.

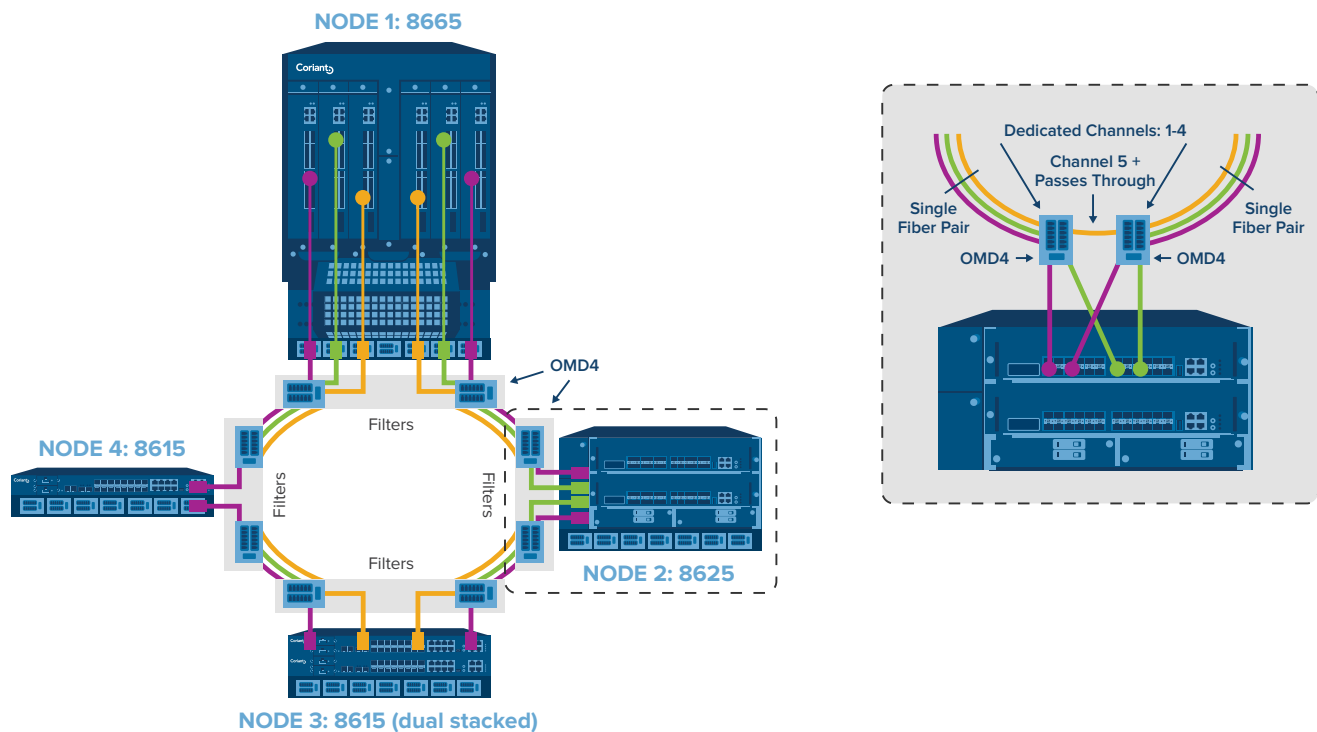


Figure 9: IP-Optical Configuration Example

Figure 9 includes a configuration example of the 8600 Series IP-Optical transport platforms in the access domain and illustrates the advantages of the Infinera solution. Each node is configured with the passive optical transport components from the Pluggable Optical Layer. Each site supports one dedicated optical channel and one shared optical channel. For Nodes 2, 3, and 4, one dedicated channel is used as a direct optical channel between each node and the aggregation Node 1. Furthermore, one optical channel is used as a shared optical channel between each network element. The shared channel is used for the exchange of traffic between the nodes belonging to this ring configuration, e.g., for X2 traffic in LTE networks.

INFINERA 8665 SMART ROUTER

The Infinera 8665 Smart Router is a cost-efficient future-proof multi-layer IP/MPLS routing platform for high speed fixed mobile convergence (FMC) networks that can optionally extend to the optical transport layer. Providing Ethernet interfaces from 1 to 100 Gbps and offering 1.2 Tbps full duplex switching capacity with 900 Gbps redundant capacity, the 8665 Smart Router is designed for deployment in medium-sized aggregation and large mobile macro sites as well as controller and S-GW sites in advanced all-IP networks. The 8665 Smart Router provides the flexibility and capabilities to serve all-IP mobile and fixed networks including applications such as traditional consumer, enterprise, machine-to-machine connectivity, and cloud networking needs. While maintaining high quality for low latency voice traffic, the 8665 Smart Router offers the interface density, throughput, and cost effectiveness to meet the needs of fast growing data services.

INFINERA 8660 SMART ROUTER

The Infinera 8660 Smart Router is an IP/MPLS-based router designed to fulfill the most demanding requirements of service providers. Due to its distributed switching and modular architecture, the 8660 Smart Router has a low initial cost of deployment and high scalability for all locations within the mobile network between the core network and local exchange sites. The 8660 Smart Router offers a complete feature set for smart migration towards LTE and full support of both 3G and 2G while providing a smart migration path towards FMC. The 8660 Smart Router supports various interfaces from 10G Ethernet to channelized TDM, ATM, and POS and offers full redundancy in service provider networks.

INFINERA 8630 SMART ROUTER

The Infinera 8630 Smart Router is similar to the 8660 Smart Router but with a more compact form factor. Following the same cost-efficient architecture and full redundancy options as the 8660 Smart Router, the 8630 Smart Router has been specifically designed to offer the functionality needed in mobile networks and its optimized size makes it ideal for use in operator sites with limited space. The 8630 Smart Router supports various interfaces from 10G Ethernet to channelized TDM, ATM, and POS and covers the diverse technology requirements of the mobile evolution.

INFINERA 8625 SMART ROUTER

The Infinera 8625 Smart Router serves as a step forward in the carrier drive towards 5G and high speed fixed mobile convergence (FMC) networks. It supports a non-blocking 400GbE switching capacity spread between redundant line cards. In a future release, the platform will scale to 1 Tbps and leverage the Pluggable Optical Layer to deliver terabit speed in access and aggregation networks. To effectively support advanced LTE-A and 5G air interface technologies, the 8625 Smart Router is equipped with an industry-leading range of network synchronization options that can be further optimized with low latency optical transport. The compact 300 mm deep chassis and power efficient design are ideally suited for installations in metro and access networks. Support from both the Transcend Chorus network management system and the Transcend Symphony multi-vendor SDN controller provides a broad array of operational efficiencies and programmable network automation. The 8625 Smart Router has been designed with the future in mind for WAN service providers.

INFINERA 8615 SMART ROUTER

The Infinera 8615 Smart Router is a cost-efficient, 44 Gbps full duplex IP/MPLS router targeted for packet networks. It combines IP/MPLS and optical transport on a single platform by integrating the Pluggable Optical Layer solution. The 8615 Smart Router is designed for aggregation and large mobile macro sites in technically advanced all-IP networks. The 8615 Smart Router provides high 1GbE interface density for mobile or fixed access networks. In addition, it efficiently aggregates the uplink traffic flows to 10GbE links toward the core. The capacity of the 8615 Smart Router can be extended by deploying a carrier-class stacking solution with two 8615 Smart Router chassis creating a single network element with 88 Gbps of full duplex capacity and control plane redundancy. The 8615 Smart Router provides the flexibility and capabilities needed to serve all-IP mobile and fixed networks, including applications ranging from traditional consumer, enterprise, and machine-to-machine connectivity to cloud networking needs.

INFINERA 8611 SMART ROUTER

The Infinera 8611 Smart Router is a compact 2RU device offering an ideal fit for small hub and aggregation sites in the Ethernet backhaul network with superior IP/Ethernet and multiservice functionality. The 8611 Smart Router provides full redundancy, modular design, and high scalability with 10GbE, 1GbE, and E1/T1 interfaces. Providing full control and forwarding plane redundancy and a fully modular architecture, the 8611 Smart Router is an environmentally hardened network element capable of being deployed in various locations.

INFINERA 8609 SMART ROUTER

The Infinera 8609 Smart Router is a 1RU cell site-optimized network element that scales up to 7.5 Gbps throughput capacity. It offers a compact IP/MPLS aggregation platform for enterprise, campus, and mobile backhaul applications and supports 1GbE and E1/T1 interfaces. The versatile service capabilities of the 8609 Smart Router including Ethernet, legacy transport along with IP VPN, MPLS switching, IP routing, and VLAN switching enable seamless integration in all existing and future LTE and 5G network scenarios. With its environmentally hardened compact design, the 8609 Smart Router can be installed at various locations and where rack space is limited.

INFINERA 8603 SMART ROUTER

The Infinera 8603 Smart Router is a cost-efficient, 60 Gbps capacity router targeted for 5G and high speed fixed mobile convergence (FMC) networks. The compact 1RU chassis and power efficient design are ideally suited for installations in access and aggregation networks. The 8603 Smart Router provides high 1GE interface density for mobile or fixed access networks. In addition, it efficiently aggregates the uplink traffic flows to 10GE links toward the core and also provides the 1GE PoE ports to connect wireless access points, IP cameras, and VoIP phones. Support from both the Infinera network management system, Transcend Chorus, and the Infinera multi-vendor SDN controller, Transcend Symphony, provides a broad array of operational efficiencies and programmable network automation.

INFINERA 8602 SMART ROUTER

The Infinera 8602 Smart Router is an optimized cell site router for macro and small cell backhauling. With support for an extensive Ethernet and IP/MPLS feature set, the 8602 Smart Router offers optimal functionality as a customer premises device for business services. The device extends the Smart Router portfolio to the access network and enables operators to use IP/MPLS as a unified technology down to small cell sites. The 8602 Smart Router is an extremely compact IP/MPLS and Ethernet device that meets various networking needs. Four variants of the 8602 Smart Router are available. The 8602-A provides two optical SFPs and four electrical Gigabit Ethernet ports for access and network connectivity. The 8602-D variant offers six Gigabit Ethernet interfaces, all SFP-based. The 8602-AS and 8602-DS are shorter versions of the product suitable for indoor use. With all four variants, the 8602 Smart Router is a perfect fit for IP or Ethernet traffic aggregation with full QoS awareness and IP routing capabilities.