TRANSFORMING
METRO
NETWORKS

Extending the scale, flexibility and programmability of the Infinera with application-specific solutions for network operators

infinera®

The New Network Model

THE NETWORKING WORLD is undergoing a transformation of its existing infrastructure. Proprietary hardware and software appliances that perform network functions focused on the upper layers of the Open Systems Interconnect (OSI) model are transforming into software instances running on standardized server hardware (x86) servers in cloud data centers through network function virtualization (NFV). This transformation to an on-demand delivery model and from specialized, proprietary platforms to open, software-enabled cloud services is referred to as Layer C. The data centers supporting these cloud services need to be connected to each other as well as to end-users. Today this connectivity is provided by a plethora of proprietary devices operating at the lower layers of the OSI model. In order to support Layer C, cloud data centers and end-users need to be interconnected by a highly scalable and flexible transport network, referred to as Layer T. Layer T is the transformation of disparate transport systems into an integrated, scalable packet-optical transport layer as shown in Figure 1.

Industry analysts have highlighted the unrelenting growth in bandwidth demand across subsea, long-haul and metro networks, and have identified east-west data center-to-data center traffic as a key driver. While long-haul networks have already started transitioning to 100 gigabits per second (100G), the explosive growth in traffic and a shift to cloud-based delivery of applications is now forcing a similar transformation of metro networks from 10G to 100G. Numerous applications are on the cusp of being virtualized, such as cloud radio access networks (C-RAN) in mobile networks and the move toward remote physical layer (PHY) in cable networks. These applications are leading to the creation of mini data centers closer to the end-user, and a shift toward a cloud-based infrastructure across the metro network. As metro network architectures evolve to Layer C and Layer T, the strategic importance of the transport layer has never been higher, and as a consequence it is vital to build Layer T with the right attributes:

• **Layer T** is built on a foundation of **scalable optics**. It requires best-in-class, right-sized optics, including photonic integration, offering high bandwidth with low space and power consumption.

• Next-generation services require **flexible and granular control** across the end-to-end packet-optical network to satisfy the unique needs of each service with application-specific capabilities. The rich suite of multi-service applications in operator networks require the appropriate use of the techniques of packet, optical transport network (OTN), optical wavelength-division multiplexing (WDM) transmission and switching. The network needs to deliver the highest available efficiency combined with key capabilities such as low latency, superior synchronization performance and multi-service transport.

• Layer T needs to be **open, programmable and agile,** with software defined network (SDN) control and open application programming interfaces (API) for rapid service creation and delivery along the lines of the new DevOps model of engineering and development.
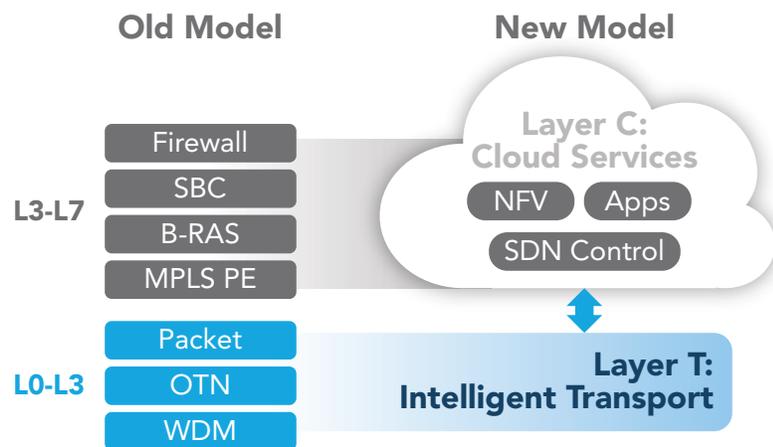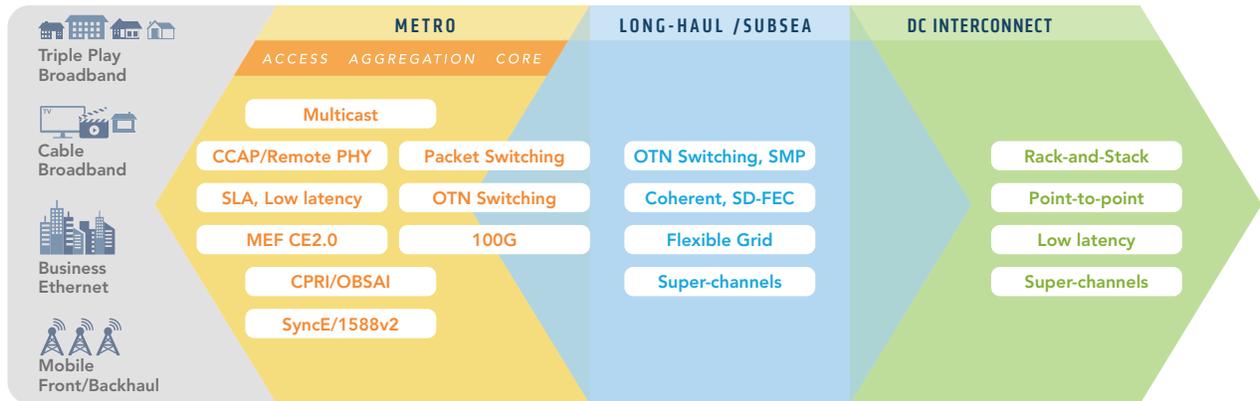

Figure 1: Network Transformation

	METRO	LONG-HAUL /SUBSEA	DC INTERCONNECT
Triple Play Broadband	ACCESS AGGREGATION CORE		
	Multicast		Rack-and-Stack
Cable Broadband	CCAP/Remote PHY — Packet Switching	OTN Switching, SMP	Point-to-point
	SLA, Low latency — OTN Switching	Coherent, SD-FEC	Low latency
Business Ethernet	MEF CE2.0 — 100G	Flexible Grid	Super-channels
	CPRI/OBSAI	Super-channels	
Mobile Front/Backhaul	SyncE/1588v2		

Figure 2: Diverse Network Requirements

Diverse Requirements

The move to 100G and beyond for long-haul and data center interconnection (DCI) applications is well underway. Networks are now seeing pressure for metro data rates to jump to 100G. Metro packet-optical networks are often application-specific, being closer to the service origination points, which are diverse, ranging from end-points like digital subscriber line (DSL) or cable modems, fiber customer-premise equipment (CPE) and mobile cell towers. Metro applications include triple-play aggregation, cable broadband aggregation, business Ethernet, mobile fronthaul and backhaul, enterprise and DCI. Each of these applications requires specific capabilities—for example mobile backhaul requires very low latency and synchronization. For business Ethernet services, characteristics such as prioritization, service operations, administration and management (OAM) and service level agreements (SLA) become critical. To meet these requirements, a variety of packet-optical tools customizable for these services are available for network designers and engineers as illustrated in Figure 2.

Infinera's application-specific metro packet-optical solution is purpose-built, employing the three key attributes of Layer T as outlined in the preceding section. It addresses the unique require-

ments of the metro and seamlessly connects with the long-haul core to deliver an Intelligent Transport Network that enables a scalable, flexible and programmable Layer T.

The Infinera End–to-End Intelligent Transport Network Portfolio

Infinera's unified end-to-end Intelligent Transport Network portfolio expands on two existing platforms that have been at the leading edge of their respective markets for over a decade. In the metro market, Infinera is a pioneer of metro WDM through the XTM Series, which today includes leading packet-optical metro access, aggregation and core platforms and is complemented by the XTG Series passive WDM platforms. These deliver optimized services for applications such as triple-play broadband aggregation, cable broadband aggregation, business Ethernet and mobile backhaul and fronthaul.

In the long-haul market, the DTN-X Family is the world's only commercial 500G super-channel system based on large-scale photonic integrated circuit (PIC) technology. The DTN-X XTC-4 and XTC-10 Platforms are joined by the new DTN-X XT-500 Platform, optimized for high-bandwidth long-haul interconnect applications, and the new DTN-X XTC-2 and XTC-2E Platforms, which extend the DTN-X Family to metro core and regional applications. All platforms in the DTN-X Family are fully interoperable over the common Infinera FlexILS™ line system.
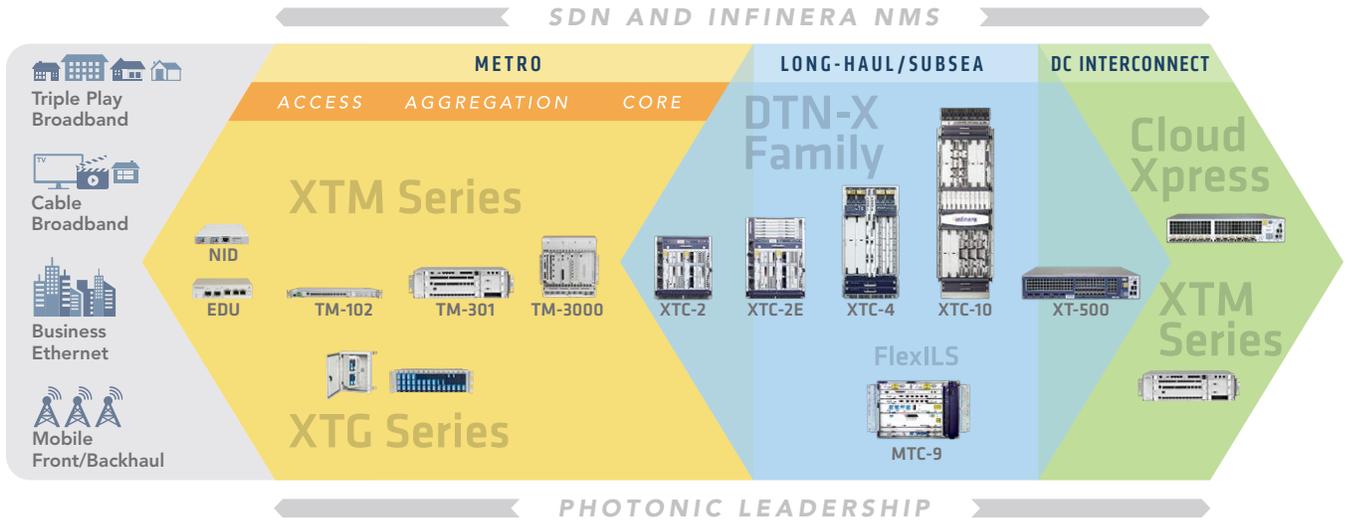
Figure 3: Infinera's Intelligent Transport Network Portfolio

To complement the company's strengths in metro and long-haul networking, Infinera moved into the metro DCI market with the Cloud Xpress Family, offering hyperscale density with 500G of super-channel capacity in a two-rack unit (2RU) rack-and-stack form factor, low power consumption and simple operations.

The Infinera Intelligent Transport Network portfolio is integrated with the foundation of scalable photonics, granular switching and the simplicity of an open, programmable control and management plane to deliver additional network applications in the future. The portfolio provides a rich set of customizable tools to meet the requirements of specific applications and network locations.

Infinera Metro Solution

The Infinera Intelligent Transport Network portfolio provides an end-to-end solution including long-haul, DCI and metro platforms. Key highlights of the platforms for the metro solution are reviewed below.

XTM Series

The XTM Series packet-optical networking platform for carrier-grade transport enables high-performance networks. Whether it's used to push WDM all the way up to the antenna or to the cell site in mobile networks, to connect enterprises together or to the cloud or to deliver high definition TV (HDTV), the XTM Series delivers a comprehensive set of capabilities to meet provider requirements in a metro network architecture designed to be flexible and highly-scalable. Supporting optical wavelengths up to multi-protocol label switching – transport profile (MPLS-TP), using technologies such as Ethernet, OTN, synchronous digital hierarchy/synchronous optical networking (SDH/ SONET), and Intelligent WDM (iWDM™), the XTM Series builds on key design philosophies such as low power, high density and a high level of scalability. It offers a multitude of advanced capabilities that make the platform highly suitable for a number of key applications. Examples include:

XTM SERIES

PT-Fabric

- MEF CE 2.0-certified for business Ethernet services, small cells and mobile backhaul
- MPLS-TP with 960G non-blocking switching
- As low as 0.2 Watts per Gig
- High density design
- Low power design
- Superior sync design
- Low latency design

Figure 4: The Infinera XTM Series and PT-Fabric

- Superior sync capabilities that are vital in mobile backhaul, especially as networks evolve to support Long Term Evolution Advanced (LTE-A)

- Support for Common Public Radio Interface (CPRI)/Open Base Station Architecture Initiative (OBSAI), enabling WDM in C-RAN architectures and mobile fronthaul

- iWDM-PON, Infinera's WDM passive optical network (PON) solution, enables scalable access networks that are easy to install and configure, making them ideal for fiber to the x (FTTx) business access applications

- Intelligent small form-factor pluggables (iSFP), enabling transparent delivery of SDH/SONET services over a packet-optical architecture, and eventually a smooth migration of legacy time-division multiplexed (TDM) networks to a common TDM/Ethernet network that fulfills strict synchronization and availability requirements

- Forward error correction (FEC), OTN transport, Ethernet, MPLS-TP, and long-reach optics all on one packet-optical transport switch module

The PT-Fabric will provide terabit-scale packet-optical transport switching that is compatible with the installed base of Infinera

XTM Series platforms and will offer up to 960G of non-blocking switching capacity, with a rich set of Metro Ethernet Forum (MEF) Carrier Ethernet (CE) 2.0 and MPLS-TP service options. The feature set is compatible with the existing range of Ethernet Muxponder (EMXP) packet-optical transport switches, and expansion is achieved using an innovative frontplane technology.

DTN-X XTC-2 and XTC-2E Platforms

The DTN-X XTC-2 and XTC-2E are purpose-built platforms to extend the DTN-X experience from long-haul into metro core and regional networks in a compact form factor. These platforms deliver a next-generation converged packet, OTN and WDM solution for metro core and regional applications, providing high capacity 100G WDM transport and OTN switching with packet-awareness. The WDM line-side modules that plug into the XTC-2 and XTC-2E are built with the Infinera FlexCoherent® Processor and Infinera's PIC technology, which is optimized for the metro 100G application with the new oPIC-100.

The XTC-2 and XTC-2E support a wide range of client-side interface speeds, from 155 megabits per second (155M) to 100G, and
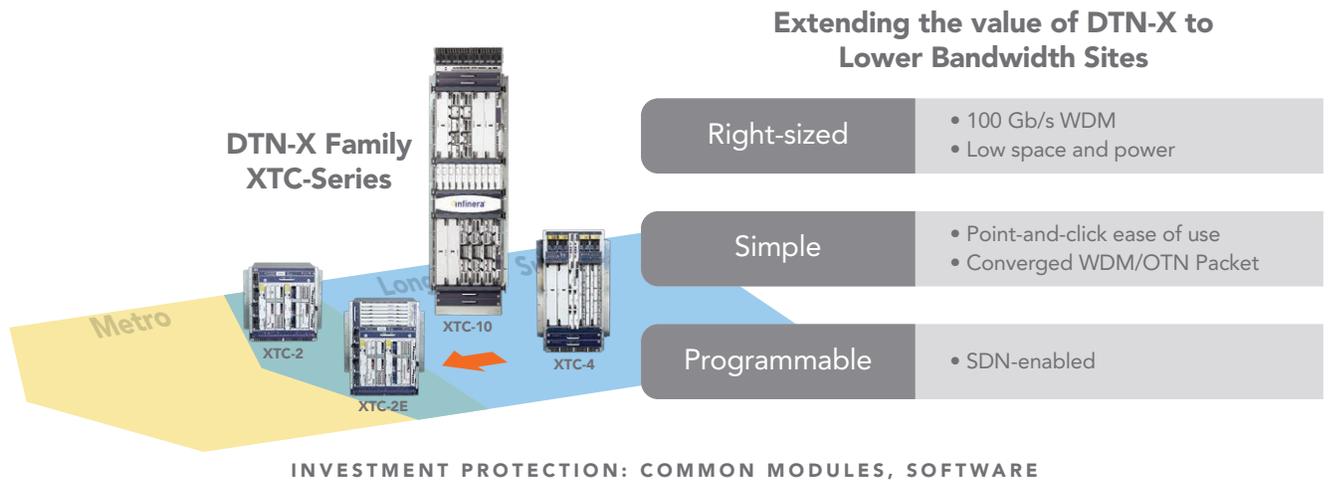

Figure 5: The Infinera DTN-X XTC-2 and XTC-2E Platforms
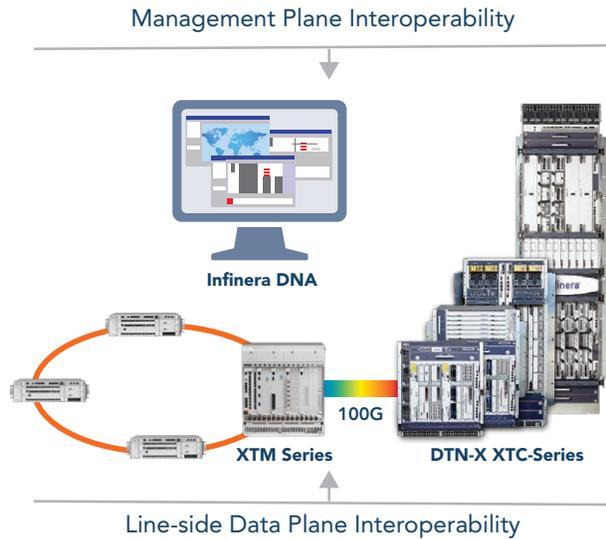
Figure 6: Interoperability Between XTM Series and DTN-X XTC Series

multiple services: traditional SDH/SONET, Ethernet/packet, storage area network (SAN), Fibre Channel, and video.

The XTM Series, DTN-X XTC-2 and XTC-2E are purpose-built met-ro platforms that feed into a DTN-X core. Service providers often have different architectural approaches, and virtually all variations and associated requirements can be met with Infinera's metro portfolio. The XTM Series provides packet-optical technology with OTN transport and Ethernet switching but no OTN switching. The DTN-X XTC-2 and XTC-2E support integrated WDM and OTN switching. The XTM Series and the XTC are fully complementary and will have line-side interoperability and common management through the Infinera Digital Network Administrator (DNA) man-agement system, as shown in Figure 6.

Cloud Xpress Family

The Infinera Cloud Xpress Family is purpose-built for scale, very low power and simplicity using optimized PIC technology in a rack-and-stack server-like form factor. The Cloud Xpress is very well-suited to handle massive traffic flows between metro data centers over a 500G super-channel supporting 10, 40 or 100 gigabit Ethernet (GbE) ports, which are the standard interfaces for client-side connectivity. The Cloud Xpress is designed to provide a terabit of input/output (I/O) capacity in just 2RU while using about 1W per Gb/s of traffic.
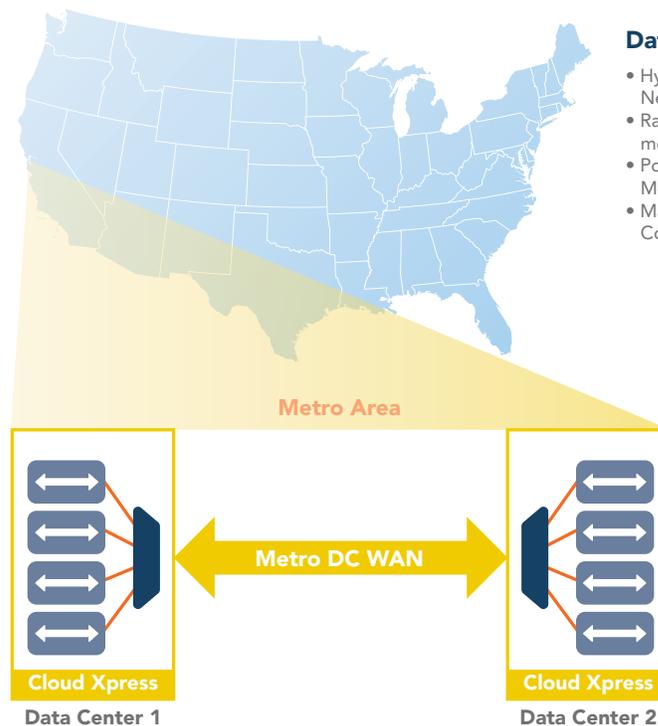
Data Center
- Hyperscale for Compute, Storage, Network
- Rack-and-stack Philosophy for Deploy-ment Speed
- Point-to-point WAN connectivity within a Metro
- Massive Bandwidth, Low Power Consumption
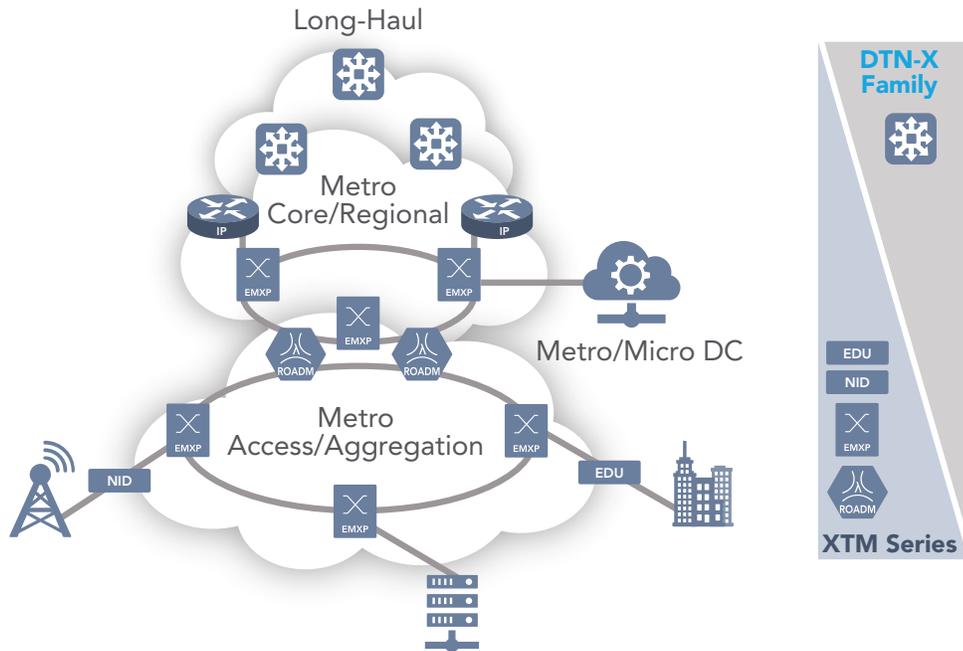
Figure 7: Infinera Cloud Xpress

Figure 8: Infinera Intelligent Transport Network Metro Architecture

XTG Series

The XTG Series is a family of passive optical WDM products. Designed for access applications, it fits in a wide range of applications from controlled environments in central offices to street cabinets or even underground enclosures such as manhole applications that require environmentally hardened products. The XTG Series supports point-to-point, mesh, bus and ring-based network topologies and can be used in a number of network scenarios such as fiber to the curb (FTTC), fiber to the building (FTTB) and high-security access networks. The XTG Series is fully compatible and interoperable with the XTM Series.

Infinera Unified Metro Portfolio

Infinera Intelligent Transport Networks provide scalability, flexibility and programmability from subsea to access. As metro networks transform to 100G, Infinera's portfolio provides a precise set of tools to address specific network location and application requirements. As metro networks transform to the new model of Layer C and Layer T and the deployment of 100G solutions, the Infinera Intelligent Transport Network portfolio provides network operators a precise set of tools to address specific network location and application requirements while scaling bandwidth, accelerating service innovation and simplifying optical network operations.

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