LAYER C AND LAYER T: A NEW NETWORKING MODEL FOR THE CLOUD

The pervasive availability of low-cost and high-powered computing, combined with the compelling benefits of virtualization, is prompting service providers to virtualize as many applications, services and network functions as possible. However, some network functions, such as optical transport, switching and traffic aggregation, are purely physical, and Infinera believes this will remain so.

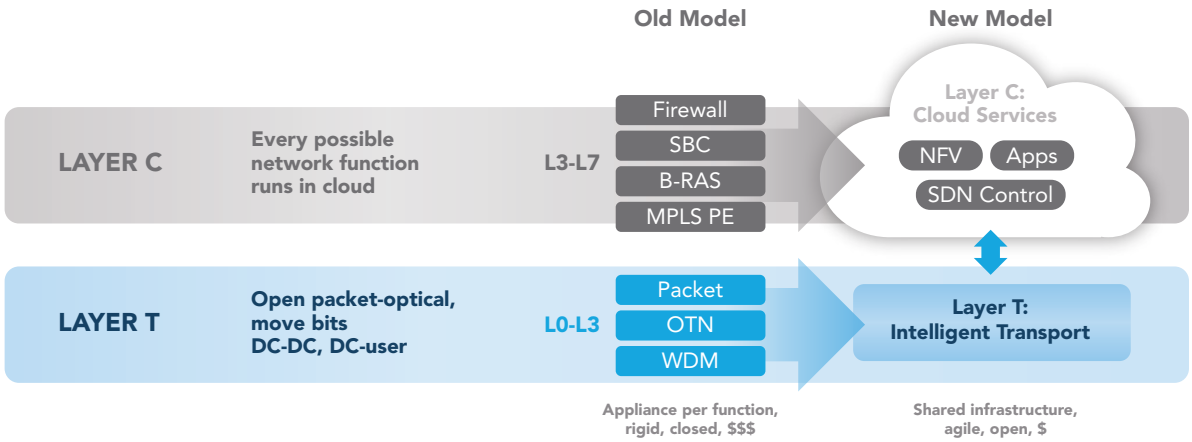
This rapid shift, in which the worlds of both virtual cloud-based network functions and scalable hardware-based network functions are emerging, is leading to a new two-layer model optimized for cloud scale networking, referred to as Layer C (the cloud services layer) and Layer T (the intelligent transport layer).

The Roots of the New Model: Virtualization and the Rise of the Cloud

The new model traces its roots to the advent of virtualization in servers, which allows software to be decoupled from specific server hardware. Combined with exponential increases in storage and compute capacity as well as network bandwidth, virtualization enables what we now call "the cloud," a scalable pool of interconnected general-purpose computing and storage resources that fundamentally changes the way IT applications can be developed and delivered. Enterprises and providers of content and applications are all moving to a mix of public, private and hybrid cloud infrastructures to improve end user experiences, increase productivity and reduce costs. Based on its many benefits, the cloud is expected to be the dominant architecture well into the foreseeable future.

The rise of virtualization and cloud-based architectures is creating opportunities to change the way networks are designed and built, delivering scalability with increased simplicity and operational efficiency to cope with a new set of performance requirements and the relentless growth in devices, data, applications and traffic. A few examples:

- A variety of software-based networking functions that were previously embedded in proprietary network devices have started



The New Two-layer Model

to move into the cloud as virtualized network functions (VNFs), a process known as network functions virtualization (NFV). Many functions are well on their way to being fully virtualized, from virtual firewalls and security services to virtual evolved packet core (vEPC) for mobile networks and virtual customer premises equipment (vCPE) for enterprises.

- Enterprise wide area networks are increasingly being architected as software-defined wide area networks (SD-WANs), with virtualized network control planes that are agnostic to the underlying network hardware or services.
- Even the fundamental routing and switching control plane software that has been tightly coupled with packet forwarding hardware is being virtualized and decoupled using software-defined networking (SDN) principles. In a pure SDN environment, all routing and forwarding decisions, including creation of virtual private network (VPN) tunnels and overlays, reside in the cloud (instead of in each network element) and are used to program simple optical switching and packet forwarding rules into the network. SDN is spreading from its origins in data center switching to transform every aspect of enterprise and service provider networking.

These trends point to a future architecture in which all network functions that can be virtualized, including switching and routing control software, are running in the cloud, and the physical network hardware is streamlined and optimized around efficient packet-optical transport. That future architecture is the basis for the new, simplified networking model, Layer C and Layer T.

Layer C and Layer T – The New Two-layer Model

In the new two-layer model, cloud services comprise one of the two layers. Incorporating public, private and hybrid cloud infrastructures, the distinguishing characteristic of this cloud services layer, or Layer C, is virtualization of applications, services and network functions running on commodity computing hardware. As noted above, most of the various network functions previously delivered in proprietary hardware platforms are now also being made available as software instances running on standardized x86 servers.

For carriers and service providers, virtualization of network functions, services and applications is enabling the transformation to an on-demand delivery model that is more agile, scalable and affordable than an architecture built on proprietary platforms.

The cloud data centers that constitute Layer C need to be connected to end users as well as to one another in distributed computing environments. This connectivity has been implemented to date by a plethora of open and proprietary devices providing basic transport, switching and routing, as well as a variety of other network functions. Steady advances in photonic and packet switching technologies, combined with the virtualization of many network functions in Layer C, have now made it possible to consolidate the movement or transport of all traffic into a single intelligent transport layer, or Layer T.

Layer T delivers traffic from its origin to its destination, extending from metro access and aggregation through metro core, long-haul and subsea networks, and into data center interconnect (DCI). This ability to architect an end-to-end intelligent packet-optical transport network further facilitates the transformation to an on-demand delivery model for network operators, including internet content providers (ICPs) and communication service providers (CSPs).

The most important characteristic distinguishing Layer C from Layer T is that the basic functions performed in Layer T are physical. Photons and bits must be transmitted between physically separated locations, most often using fiber optic transmission. Building large-scale, economically efficient networks that maximize the use of optical transport capacity also requires multiplexing many traffic flows and using optical, digital or packet switching to forward the photons and bits to the right destination. Packet-optical consolidation at Layer T provides greater agility, scalability and affordability than the traditional multi-layer networking model, just as virtualization does at Layer C.

The continuing growth of Layer C applications and services imposes three requirements on Layer T: greater scalability, more flexibility and programmability. The need for scalability with a virtually infinite pool of bandwidth is enabled by advances in Infinera's photonic integrated circuit (PIC) technology, while Infinera's packet-optical transport systems provide granular flexibility. Infinera's Xceed Software Suite, Instant Bandwidth and Instant Network offerings serve as examples of

how multi-layer control, open interfaces and programmability extend SDN all the way to the optical layer, streamlining operations, accelerating service turn-up and enabling software defined capacity (SDC).

Layer C and Layer T: The Foundation for Cognitive Networking

Infinera is building solutions to support this new two-layer model. The most cost-effective way to move bits around the network is clearly optics, and thus they must be the foundation for Layer T. Infinera is leveraging advances in the company's photonic integrated circuits and coherent digital signal processor (DSP) technologies, which constitute its Infinite Capacity Engine family, and combining it with the right amount of packet-switching silicon, SDN, open interfaces, SDC and other technologies to deliver truly transformative solutions.

Networks architected according to Layer C and Layer T principles will achieve increased network scalability, efficiency and simplicity, with full automation across the intelligent packet-optical transport infrastructure. This model will ultimately support a move to cognitive networking, in which the Layer T intelligent transport network leverages cloud-based path computation, analytics and control to deliver a self-aware, self-organizing and self-optimizing network that can take predictive and prescriptive actions to provide autonomous, automated and on-demand transport services to Layer C.

To learn more about how Intelligent Transport Networks are helping to fulfill the promise of this transformative two-layer model, please contact Infinera at https://www.infinera.com/company/contact-us/.

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