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White Paper

DCI-Optimized Technology Solutions: The Next Wave

Muhammed Sarwar, Distinguished Engineer,
Fujitsu Network Communications, Inc.

Data Center Interconnect (DCI) applications have been the driver for a major technological shift in optical transport over the past five years as Internet Content Providers (ICPs), enterprises and communications service providers have wielded increasing purchasing power. These applications have been the focus of architectural, equipment and component design developments to support the stringent density, scalability, energy-efficiency, and capacity requirements of DCI. The expanding prevalence of purpose-built optical DCI solutions owes itself to technological maturity in areas such as coherent optics, Digital Signal Processors (DSPs) and Analog Coherent Optics (ACO) with fixed modulation rates up to 16QAM.

While some of the new developments–such as client and Link-Level Discovery Protocol (LLDP), Remote Network Monitoring (RMON), and Layer 1 encryption–are already integrated into DCI solutions, more developments are on the horizon. These developments will be driven in large part by the ever-present downward pressure on cost-per-bit and power consumption, as well as the need to control total cost of ownership (TCO).

Is the "Big, Fat, Dumb Pipe" a Thing of the Past?

DCI was originally all about what are colloquially termed "big fat dumb pipes" that connect data centers hundreds to thousands of kilometers apart. Now, however, these "dumb" pipes are gearing up to become smarter as well as bigger–smarter as in more flexible, more functionally rich, and more programmable across Layers 0–3. Big fat smart pipes are the future for DCI applications.

Given the forecast of enormous expansion in the scope and diversity of cloud applications over the coming decade, it should come as no surprise that data center transport will need to advance in order to keep up with demand and keep up with rising customer expectations. Enterprises moving their services and applications into the cloud–and consumers who depend on cloud-based shopping, banking, content delivery and other services–already demand seamless connectivity, sometimes among multiple data centers spread over large geographical areas.

Virtualization; automation; "conscious" networking; centralized remote management; and self-healing/self-optimization capabilities are all examples of cutting-edge development efforts that will benefit greatly from richer features at the optical transport level.

Increased Flexibility and Coordination among Layers

The relationships and interfaces among standard speeds and feeds at each of the various network layers results in successive levels of granularity, imposing cumulative overhead that limits the agility of data center networks. This is especially notable where links are bonded together (for aggregation, when the overhead of traditional link aggregation is not desirable) or sub-rated (Media Access Control (MAC) can operate at variable rate).

The increasing mixture of pipe sizes, protocols, and client/network interface types is imposing a significant burden on network management and network design. Incompatible pipe sizes across layers further amplify the granularity problem. There is a need for integrated controls for each of Layers 0–2, to manage aspects such as configuration, redundancy, and sizing. There is an additional imperative to further collapse the functions of these three layers to make things simpler, and to address the limitations imposed by granularity among the different layers. Flexible sizing is also a highly advantageous capability.

Upcoming Optical Transport Developments

The next wave of coherent Digital Signal Processors (DSPs) will offer a range of new possibilities for reach, capacity and spectral efficiency that enable much more agile approaches to network design.

Flexible modulation schemes with variable modulation and baud rates at Layer 0 will increasingly optimize utilization of fiber assets by enabling selection of the most appropriate modulation scheme for the desired reach, capacity, applications, and performance. At Layer 1 (OTN), ODUFlex can now provide a flexible (rather than fixed-size) OTN container. This overcomes an important limitation that has prevented use of OTN in DCI applications.

Flex-E (Flexible Ethernet) is now providing an option to decouple MAC from Ethernet PHY, hence allowing MAC rates to be variable at 5G granularity, regardless of the PHY rates. Flex-E, therefore, opens up the capability for Ethernet pipes to be sized dynamically. Combining Flex-Lambda with ODUFlex and Flex-E now has the potential to achieve the ultimate goal of coordination and adjustment of pipe sizes across Layers 0–2 at the data path level, obviously with coordinated, smart software controls.

An earlier concept of managing transponders with a variety of configuration options that operators can evaluate and experiment with, is already becoming reality with a combination of next-generation DSPs and optics. However, greater value can be achieved by extending this concept across Layers 0–2, such that operations and management work seamlessly across layers and provide more coordinated and coherent DCI pipes.

Towards More Efficient, Open Network Architectures

For today's typical data center architecture, DCI infrastructure (transponders and line systems) is statically connected to the packet infrastructure within the data center. Future DCI applications will build on current SDN/NFV technology to emphasize open platforms and interfaces, flexible client grooming and cross-layer capabilities. It will also become possible to add cross-connectivity in transponder elements that can map any client port to any network port, enabling a variety of new use cases and more effective utilization of client ports across wavelengths that can carry 100G to 600G in 50G granularity on a network port. Without such connectivity, although line-side ports can already provide flexible rates, it is necessary to compromise on space or spectral efficiency.

Openness in terms of both software and equipment/components is an essential aspect of DCI architecture, and this will continue to be the case. Effectively meeting the machine-to-machine demands of the Internet of Things (IoT) and lowering costs enough to deliver near-universal access to connectivity are impossible to achieve without solving the burden of vendor lock-in.

Automation, Virtualization and SDN/NFV Applications

Software-defined, virtualized, programmable networking has been a priority in the data center world for some years now, and this will continue to be the case. Important developments in DCI will favor increasingly sophisticated capabilities for coordinated and automated/assisted discovery and configuration, in addition to optical networks that are more self-aware and intelligent. This means it is necessary to harness and simplify the additional flexibility and rich feature set that come with new transport technologies.

Conscious network applications will ultimately influence every point in the network operations cycle, from design through test and startup to runtime; these applications will speed integration and enable intelligent management and control at both the transponder and, using SDN concepts, at the network level. Examples include operations-related essentials like simplifying NE configuration – to untangle the plethora of interdependent configuration options and building blocks for optical links and automatically determine the optimal settings.

Automation thus offers immense potential and enhanced zero-touch provisioning applications are pointing the way to the next level, where for example, transponders can readjust their own capacity by changing parameters automatically (such as the modulation or error correction scheme) based on policy or system profile.

Conscious, automated networking and cross-layer optimization will also enable live network monitoring and scaling based on events, policies, or the addition of new services and links. Changes in error rates, network failures, congestion and quality degradation will all become faster and simpler to manage as networks increasingly monitor and evaluate their own performance metrics—and react or adjust automatically.

A Future Taking Shape

The next generation of DCI will employ several strategies, and the industry will continue to refine applications as the various enabling technologies line up. However, it is certain that DCI applications will become more conscious, flexible, and programmable, both from software and hardware perspective. In turn, DCI applications will combine technology advances on both optical transport and SDN/NFV to simplify and automate operations, cut total cost of ownership, increase spectral efficiency of fibers and continue to lower overall cost per bit.

Fujitsu Network Communications, Inc.

2801 Telecom Parkway, Richardson, TX 75082
Tel: 888.362.7763

us.fujitsu/telecom

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