DATA CENTER INTERCONNECT SOLUTIONS FOR LARGE ENTERPRISES

MEETING CURRENT AND FUTURE NEEDS FOR ENTERPRISE DATA CENTER INTERCONNECT

STRATEGIC WHITE PAPER

The rapid gains in data center efficiency, the emergence of mega data centers and the impact of cloud computing, as well as the virtualization of data center architecture and Software-Defined Networking (SDN) mean that large enterprises need to consider new approaches to meet current and future data center interconnect (DCI) needs.

Alcatel-Lucent provides a wide choice of DCI solutions that help large enterprises de-risk the provisioning of data center interconnect. These include high performance, low latency, secure optical WDM solutions for synchronous applications to IP/MPLS solutions that provide high performance, multi-site DCI with advanced QoS and traffic engineering for asynchronous applications. Alcatel-Lucent DCI solutions are used by many large enterprises in the financial, healthcare, consumer and industrial segments for business and mission-critical applications.

Alcatel-Lucent is also at the forefront of data center network virtualization with SDN solutions that deliver unrestricted data center networking while enabling SDN extension across the WAN – greatly simplifying operations, reducing costs and increasing agility.

Alcatel·Lucent

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INTRODUCTION

Synchronous applications, such as real-time disaster recovery and business continuity between data centers continue to drive the enterprise data center interconnect (DCI) market. For large enterprises with the highest performance, regulatory and security requirements, the preferred choice is a WDM optical solution. This approach continues to be a valid option where security and integrity of business- and mission-critical data remains central to the company's business and operations.

But other solutions are becoming available as DCI is being completely redefined. This comes as a result of rapid gains in data center efficiency, the emergence of mega data centers and the impact of cloud computing, software-defined networking (SDN) and the virtualization of data center architecture. Although these factors mainly impact service providers and telecom operators, emerging technologies in the cloud era mean that large enterprises must consider new approaches to meet future DCI needs.

DCI is expanding beyond the business continuity and disaster recovery role it has traditionally played. It is becoming a way to connect data centers in a cloud of virtualized compute and storage using SDN to automatically allocate resources, as required. The key question for large enterprises used to be: "How can I maximize the bandwidth between sites at the lowest latency and cost?" Given the rapid and dramatic market changes, the key question now is: "How can I meet my current DCI needs with a solution that encompasses virtualization, SDN and the cloud as well?"

OVERVIEW OF MARKET TRENDS

Enterprise market trends, such as increased employee mobility, the adoption of "bring your own device", "bring your own application" and the "big data" explosion are impacting future needs and requirements for enterprise data centers and DCI.

According to IDC, key growth areas for DCI will be dynamic workload scheduling and asynchronous data replication, particularly for cloud-based data centers and applications.

The enterprise data center market is also being affected by cloud computing, big data and the compelling economics of virtualization. As a result, it is undergoing a period of rapid change, growth and consolidation. According to IDC,[1] the key business drivers for enterprise DCI vary by enterprise segment. However, the most common drivers include more efficient IT resource utilization (financial services), improved end-user access to applications (government and education) and simplified data center management (industrial and consumer).

IDC found that the most common applications for enterprise DCI continue to be near real-time disaster recovery and business continuity. Future growth areas for enterprise DCI will be dynamic workload scheduling and asynchronous data replication, particularly for cloud-based applications. In addition, large enterprises need an approach that can scale to meet future needs, respond to competitive pressures, and adapt to data center virtualization, SDN and the cloud.

The changing dynamics of the data center business are also having a knock-on effect on enterprise data centers in terms of size and efficiency, future expansion and scale, as well as server virtualization and cloud services. Server virtualization and cloud services have been adopted successfully during the past few years by Internet companies, such as Amazon and Google. This so-called web-scale approach uses a virtualized, cloud-based architecture built on commodity compute, storage and network components. Combined

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1 "Highlights of IDC's 2013 Datacenter Interconnect Survey of Enterprise Datacenter Respondents", IDC, February 2014

with SDN, it enables capacity to be increased and decreased as needed by rapidly and automatically assigning and de-assigning resources. Gartner predicts that by 2017 more than 50 percent of large enterprises running their own data centers will adopt the web-scale approach to IT because of the flexibility, agility, efficiency and cost savings offered by this approach.[2] This will have a dramatic impact on large enterprises' future data center architecture and operations, as well as future DCI requirements.[3]

OPTIMAL TECHNOLOGIES FOR DCI

Different networking technologies are available to address different DCI networking challenges while supporting applications with different performance and latency requirements. The following factors need to be considered:

- The type of applications, and whether they are synchronous or asynchronous, which will have some influence on the choice of technology and its implementation.
- Overall bandwidth requirements and the distance between data centers, which could mean a trade-off between speed and cost.
- Latency requirements for mission-critical applications, which usually dictates the fastest and most efficient technology for those applications that demand the lowest latency.
- The types of client interfaces (both computing and storage), which when other factors are taken into consideration, may limit the choice of solution.

Table 1 shows the optimal Alcatel-Lucent solution and networking technology to support the requirements of different DCI applications. The applications are organized into tiers with Tier 1 applications requiring a DCI solution with the highest performance and lowest latency. Tiers are then mapped to networking technologies that can meet the underlying requirements of the application. In the following sections, the solutions are discussed in more detail.

Table 1. Optimal networking technology to support different enterprise DCI applications

ENTERPRISE DCI APP	APPLICATION PERFORMANCE REQUIREMENTS	TYPICAL APPLICATIONS	ALCATEL-LUCENT SOLUTION
Tier 1	• < 5 milliseconds latency • < 50 milliseconds restoration • < 10 Gbps bandwidth (CWDM) • ≤ 200 Gbps (DWDM) • > 50 ports (Fibre Channel, FICON and InfiniBand transport)	• Synchronous applications • Metro (<50 km) or regional (<150 km) • Business continuity and disaster recovery • Federated storage – data collaboration and migration (metro/regional) • Content delivery and video caching synchronization	Optical WDM using the Alcatel-Lucent 1830 PSS: • Short reach CWDM < 50 km < 10 Gbps • Short reach DWDM < 150 km ≤ 200 Gbps
Tier 2	• < 50 milliseconds latency • < 50 milliseconds restoration • > 20 and < 100 Gbps bandwidth • > 20 ports (Fibre Channel and Ethernet)	• Asynchronous and synchronous applications (depending on distance) • Metro, regional, national >150 km • Business continuity and disaster recovery • Tape vaulting • Bandwidth aggregation (data center consolidation) • Federated storage – data collaboration and migration (regional/national)	Optical WDM (medium or long reach DWDM) or Layer 2 Carrier Ethernet transport using the Alcatel-Lucent 1830 PSS

2   "Strategic Technology Trend: Web-Scale Singularity Means Goodbye to Conventional IT Wisdom", Gartner, February 2014
3   More details of these market trends and the impact of these trends on the large enterprise DCI market are discussed in the Alcatel-Lucent white paper, *Data Center Interconnect Market Trends and Requirements*.

ENTERPRISE DCI APP	APPLICATION PERFORMANCE REQUIREMENTS	TYPICAL APPLICATIONS	ALCATEL-LUCENT SOLUTION
Tier 3	• < 50 milliseconds latency • < 50 milliseconds restoration • < 20 Gbps bandwidth • < 20 ports (Ethernet)	• Asynchronous and synchronous applications (depending on distance) • Metro, regional or national • Server-based replication • NAS and remote tape backup • Remote office access and backup	Layer 2 Ethernet transport using the Alcatel-Lucent 1830 PSS Carrier Ethernet capabilities
Tier 4	• < 100 milliseconds latency • < 100 milliseconds restoration • < 10 Gbps bandwidth • < 10 ports (Ethernet)	• Asynchronous applications • Metro, regional, national or global • NAS and remote tape backup • Remote location access and backup • Integration with private WANs • Extending DC virtualization and SDN over the WAN	• Layer 2 Ethernet, Layer 3 IP VPNs or Business Internet Access using the Alcatel-Lucent 7750 SR • Extend DC virtualization and SDN over the WAN using the 7750 SR as a DC gateway

DATA CENTER CONNECT SOLUTIONS

Optical data center interconnect

Optical WDM is the technology of choice for Tier 1 and Tier 2 DCI applications and offers transport-grade reliability and protocol-independence to meet most DCI requirements. It is the only technology that enables full network flexibility and adaptability at speeds of 10, 40 and 100 Gbps and beyond while meeting the stringent performance, latency and reliability demands of synchronous DCI applications.

Figure 1 shows the Alcatel-Lucent 1830 Photonic Service Switch (PSS) used for optical DCI. The 1830 PSS was the first DWDM platform to enable 100G and the first to support 200G coherent optical transport on a single-carrier wavelength. Using internally developed silicon, the 400 Gbps capacity Photonic Service Engine (PSE), and technology from Alcatel-Lucent Bell Labs, the company created the 1830 PSS — a scalable, next-generation DWDM platform that supports multiprotocol data center aggregation for Ethernet, Fibre Channel (FC) and InfiniBand®. It supports both short reach CWDM and medium/long reach DWDM optical interfaces depending on requirements and distance between data centers.

BENEFITS OF THE 1830 PSS FOR DCI
- Support for virtual apps and content
- Scalable bandwidth
- Low latency with latency optimization
- Protocol independence
- Lossless transport
- High utilization with flexibility

1830 PSS DCI CERTIFICATIONS
- Approved WDM product for IBM GDPS transport
- Brocade certification
- EMC certification including VPLEX for continuous storage availability
- Tested with HP 3PAR Peer Persistence
- (FIPS) 140-2 Security Level 2 (SL2)

Figure 1. Optical data center interconnect using the Alcatel-Lucent 1830 PSS
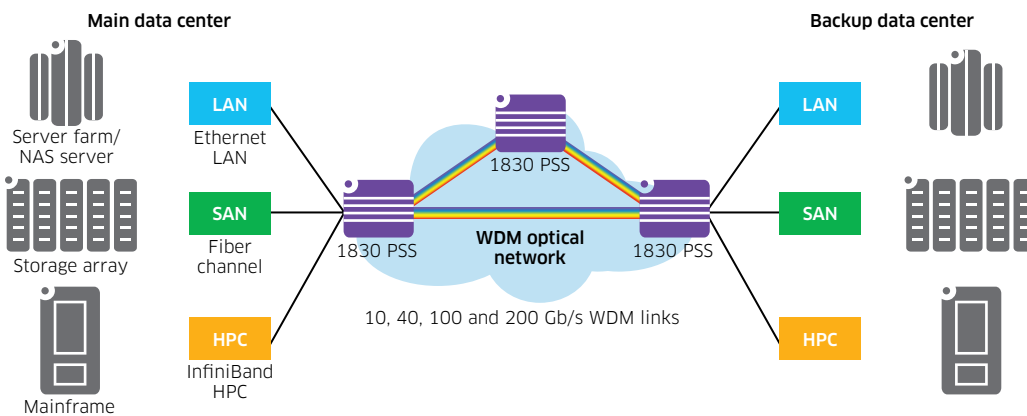
The 1830 PSS supports efficient wavelength switching between source and destination using Tunable-Reconfigurable Optical Add-Drop Multiplexing (T-ROADM). For larger enterprises with more complex requirements, the 1830 PSS supports full Layer 2 Ethernet

services over the optical network, and a Generalized Multiprotocol Label Switching (G-MPLS) control plane to enable automated set-up, provisioning, and restoration of the optical layer, decreasing costs and increasing uptime.

Wavelength Tracker is a multilayer network planning and control tool for the 1830 PSS that provides an integrated view of the optical network, making it easier to monitor performance, identify problem areas and reduce configuration errors. Wavelength Tracker automates provisioning of power levels and cross-connections, and automates and optimizes the commissioning of wavelengths. It supports sophisticated wavelength fault isolation with reporting of threshold alarms and detection of wavelength collisions and cable misconnections, eliminating many configuration errors and significantly reducing operating costs.

The 1830 PSS also supports latency optimization on its optical line cards to ensure synchronous DCI applications can be optimized depending on the distance between sites. On-demand latency measurement with hardware time-stamping can be used to check end-to-end round trip delay at network commissioning or after activating features such as line protection.

Layer 1 encryption for secure DCI

Today's data centers are continuously at risk from internal and external security threats. More than simply deploying antivirus and firewall defenses, large enterprises must establish comprehensive IT security programs that protect a virtual and distributed environment of computing and storage resources.

For these distributed resources to work effectively and meet diverse end-user requirements, applications require secure, low-latency, real-time communications with guaranteed QoS. The infrastructure and optical fibers used for DCI transport are key components of a holistic and systematic IT security program.

Encryption is the algorithmic process that transforms data into unreadable crypto text. Real-time, on-the-fly transformation is the only option for cost-effectively meeting end-user needs in an always-on world. Level 1 encryption is the preferred method for DCI, supporting higher-layer data flow across metro or long-haul optical DWDM transport. Figure 2 shows how Level 1 encryption maximizes capacity and performance for DCI over secure optical DWDM links.

Figure 2. Secure data center interconnect using the Alcatel-Lucent 1830 PSS
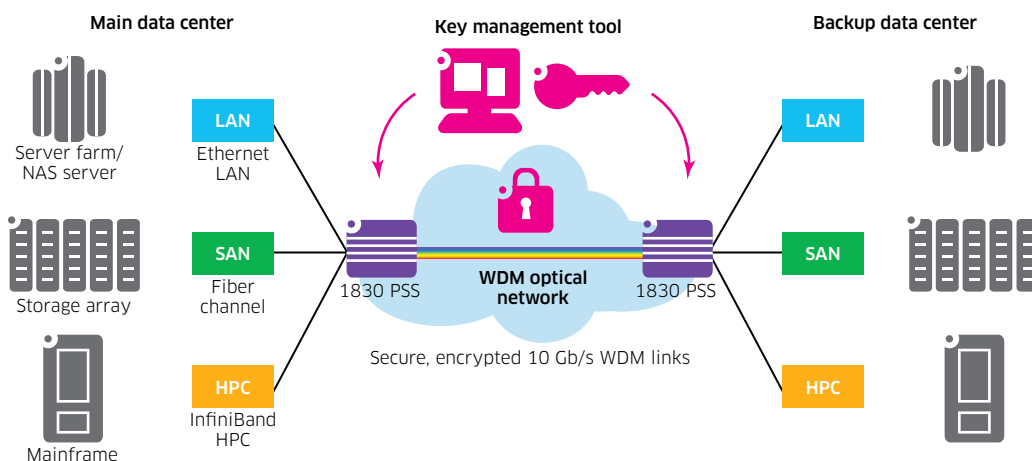
BENEFITS OF SECURE DCI
- Support for dynamic and virtual apps
- AES 256 bit hardware encryption
- Low latency adds <20 nanoseconds
- Optical intrusion detection
- Protocol independence
- Scalable to meet future demand
- Cost-effective

CASE STUDY: SECURE OPTICAL DCI FOR A EUROPEAN BANK
- Private optical solution with two separate fully redundant networks managed by NOC
- High security using AES encryption managed by bank cyber security team
- Very low latency for synchronous DCI
- RTT< 194-770us <1ms

The Alcatel-Lucent 1830 PSS supports an integrated Layer 1 hardware encryption option combined with optical intrusion detection to provide secure transport for critical DCI applications. The platform uses Advanced Encryption Standard (AES) with 256 bit hardware encryption that adds less than 20 nanoseconds of latency. A separate, secure and scalable key management tool manages the encryption keys independently of the 1830 PSS management system. This enables security management to be completely separated from optical management, allowing two different organizations to jointly manage the overall solution without compromising data confidentiality and security. For example, a bank cyber security team can manage the key management and encryption with a service provider managing the optical network.

The Alcatel-Lucent 1830 PSS can manage specific physical and logical security risks regarding individual network elements, including secure device configuration, comprehensive logs with intrusion prevention alarms, highly flexible optical interface redundancy options, and an optical intrusion detection feature that continuously monitors links for unexpected loss of signal strength from unauthorized optical fiber taping.
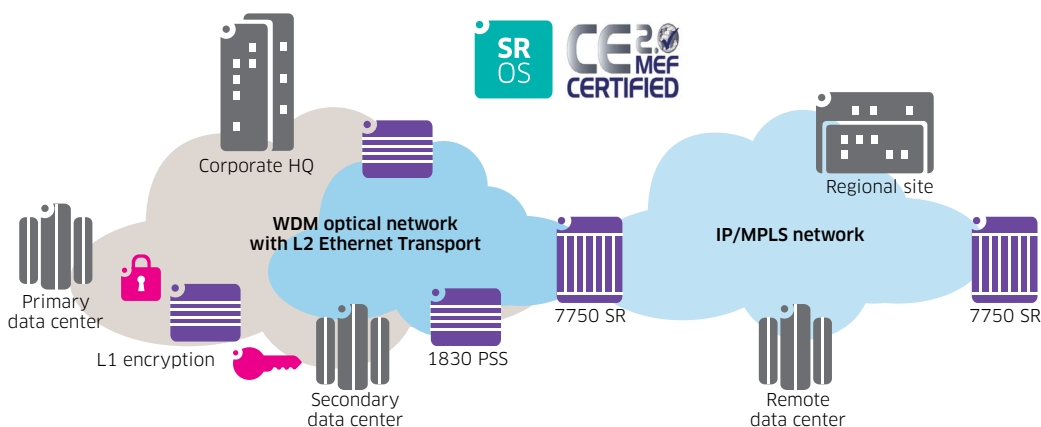
Ethernet transport for DCI

Layer 2 Ethernet transport over optical WDM can be used to provide transparent, point-to-point Ethernet Line (E-Line) and multi-point Ethernet LAN (E-LAN) and Ethernet Tree (E-Tree) connections for most asynchronous and some synchronous applications depending on latency tolerance and distance between data centers. Typical applications include backup and recovery of Ethernet-attached server farms and for network attached storage (NAS).

Figure 3 shows Layer 2 Ethernet transport over optical WDM using the 1830 PSS, which supports a range of optical interfaces, including DWDM, CWDM, 100 Gbps and 200 Gbps Ethernet. Large enterprises already using optical WDM on the 1830 PSS for synchronous DCI applications can simply add Ethernet transport capabilities with QoS, OAM and protection. This approach can provide significant cost savings when connecting multiple sites by using E-LAN or E-Tree for aggregation and statistical multiplexing of services.

BENEFITS OF ETHERNET FOR DCI
- Cost-effective option for 1830 PSS in multi-site applications
- Support for E-Line, E-Tree and E-LAN
- Fully compliant with MEF 2.0
- Ethernet functions based on Alcatel-Lucent SR-OS
- Fully compatible and common management with the Alcatel-Lucent IP/MPLS portfolio

Figure 3. Ethernet transport for data center interconnect using the Alcatel-Lucent 1830 PSS

The Carrier Ethernet transport implemented in the 1830 PSS uses the same Alcatel-Lucent Service Router Operating System (SR-OS) software used in the Alcatel-Lucent 7750 Service Router (SR) and 7450 Ethernet Service Switch (ESS). It is fully compliant with and certified to Metro Ethernet Forum (MEF) Carrier Ethernet 2.0 (CE 2.0) for E-Line,

E-LAN and E-Tree services and fully interoperable with the 7750 SR. It also uses the Alcatel-Lucent 5620 Service Aware Manager (SAM) system as the 7750 SR and 7450 ESS for end-to-end provisioning, trouble-shooting and maintenance. This enables operational savings when using Alcatel-Lucent optical and IP/MPLS solutions in the same network.
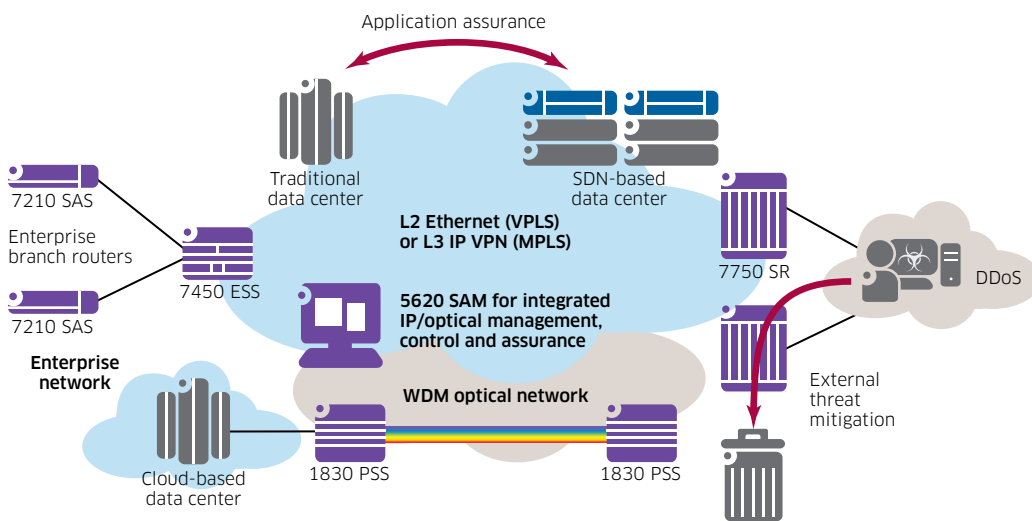
Ethernet and IP VPNs for DCI

Layer 2 Ethernet and Layer 3 IP VPNs are the technologies of choice for asynchronous data center applications that have less stringent latency, lower bandwidth and regional, national or international connectivity requirements. They are also the preferred choice for large enterprises with additional requirements, such as remote site access to applications hosted in the data center, application performance monitoring or integration with the private WAN.

Figure 4 shows Layer 2 Ethernet and Layer 3 IP VPNs implemented in the Alcatel-Lucent IP/MPLS product portfolio that includes the 7750 SR and the 7450 ESS. The 7750 SR is a high-performance, multiservice router designed for the concurrent delivery of advanced IP/MPLS-based services on a common platform, and the 7450 ESS is a Carrier Ethernet switch router designed to deliver high-performance MPLS-enabled carrier Ethernet services. The products support a wide range of LAN and WAN interfaces, including 1 Gbps Ethernet, 10Gbps Ethernet, 100G bps Ethernet, ATM and SONET/SDH.

Figure 4. Ethernet and IP VPNs for DCI using the Alcatel-Lucent 7750 SR

Designed for service provider networks and using the Alcatel-Lucent 400 Gbps FP3 silicon technology, the products deliver exceptional performance and scale for large enterprise networks to support a wide range of IP and Ethernet services. Service intelligence enables granular control of services and drives operational efficiency. Available in different chassis variants, the products support a wide range of IP/MPLS-based VPN services, such as Layer 2 Virtual Private LAN Service (VPLS), MEF 2.0-certified E-LAN, E-Line, E-Tree and E-Access and Layer 3 IP VPNs, IPv6 VPNs and multicast VPNs. The products use the Alcatel-Lucent Service Router Operating System (SR OS) and are managed by the Alcatel-Lucent 5620 Service Aware Manager (SAM) for end-to-end provisioning, troubleshooting and maintenance.

BENEFITS OF L2 AND L3 VPNS FOR DCI
- High performance and scalability
- Supports wide range of MEF 2.0 Ethernet and IP VPNs
- Comprehensive high availability and reliability
- DDoS and Application Assurance
- Integrates easily with existing enterprise WAN infrastructure

CASE STUDY: BUSINESS CRITICAL NETWORK FOR EUROPEAN BANK
- End-to-end managed national WAN and regional MAN
- Converged IP/Optical solution covering 8 data centers and 8000 branches
- Carrier grade quality and SLAs
- Highly responsive, supporting network changes in minutes at incremental marginal cost

High availability and reliability features for DCI applications

The Alcatel-Lucent 7750 SR supports highly scalable IP VPN services with unmatched performance, security and reliability for DCI applications. Redundant hardware, non-stop routing and non-stop forwarding ensure end-to-end IP VPN services are not interrupted by link failures, equipment failures, DDoS attacks and software upgrades. Link, nodal and path protection capabilities ensure highly available services and protect against service interruptions, using features such as:

- Multi-Chassis - Link Aggregation Group (MC-LAG), Automatic Protection Switching, Resilient Ring and Multilink PPP (MC-MLPPP)
- Primary and standby LSPs, MPLS Fast Reroute
- Bidirectional Forwarding Detection
- Pseudo wire dual homing and pseudo wire stitching
- MAC topology change notification and flush notification

Security capabilities across different layers include DDoS attack prevention; line-rate filtering; service mirroring; administration, routing and control authentication; logging, reporting and auditing; network traffic control; network topology analysis; Layer 2 and Layer 3 resource control on per-customer, per-service, per-port, per-module and per-platform bases; Layers 2 to 7 monitoring and application control.

Integrated IP/optical with common management and service assurance

The Alcatel-Lucent 7750 SR, combined with the Alcatel-Lucent 1830 PSS, provides a cost-effective, more efficient integrated IP/optical solution for DCI with multiple reliability and high availability features in support of business and mission-critical DCI applications, such as business continuity and disaster recovery. Fully redundant platforms with disaster recovery technologies at the IP routing and optical transport layers provide node level, network level and application level protection.

The 5620 SAM leverages multi-domain, multi-layer management to provide common management across both the IP and optical domains to unify workflows and achieve maximum efficiency. Proactive assurance and advanced monitoring capabilities across elements, infrastructure layers, and services in the integrated IP/optical network rapidly detect and isolate problems before they can impact services and end users. Integrated views across multi-domain and multi-technology layers spanning physical, routing, MPLS and IP/optical service topologies simplify and accelerate troubleshooting. End-to-end power control, monitoring, tracing and fault localization for individual wavelength channels — enabled through the Alcatel-Lucent Wavelength Tracker technology — proactively prevent service degradation by enabling delivery of true optical SLAs. Integrated IP/optical performance and SLA monitoring using comprehensive service-aware diagnostics validate end-to-end data services and IP/optical paths. Fast and easy configuration and multi-vendor scripting workflows reduce the risk of errors and speed network deployment time.

Application assurance and DCI

Two common challenges facing large enterprises are how to address performance for applications hosted in the data center and how to track application usage and bandwidth to/from the data center. Alcatel-Lucent IP/MPLS solutions meet these challenges using Application Assurance, which provides extensive application monitoring and reporting. These include:

- Hosted or cloud application performance monitoring (client to host) with granularity across multiple network segments.

- Bandwidth utilization in the data center or between any two sites on a per-application, application group or user group basis.
- Application statistics, including top bandwidth applications and top users per application
- Centralized repositories for application data collection that scale for large enterprise networks and provide the business intelligence for new service development.
- Enterprise AA Portal for visibility into both enterprise and hosted applications running over the WAN.

Application policies can be enforced across multiple touch points, including the data center, and at any point in the network. This distributed, network-based application assurance capability can also provide SLA measurement for business critical applications hosted in the data center — right down to the remote sites and users accessing the application. SLA guarantees can be provided for users while enabling performance monitoring of applications as they transit the network.

Virtualization, SDN and DCI

Alcatel-Lucent has leveraged SDN and its global expertise in IP networking to create the Nuage Networks Virtualized Services Platform (VSP). The Nuage Networks VSP enables large enterprises to build robust and highly scalable networking infrastructures within and between data centers. These new infrastructures deliver secure virtual slices of readily consumable compute, storage and networking resources to different user groups.

The Nuage Networks VSP is specifically designed to:

- Simplify operations for rapid service instantiation – Nuage Networks VSP defines network service requirements in clear, IT-friendly language. It also uses automated, policy-based instantiation of network connectivity to bring up services. This dramatically reduces time to service and limits potential for errors.
- Address changing business requirements with flexible, adaptable services – The data center has to adapt dynamically to keep up with evolving application needs. The Nuage Networks VSP detects newly created and updated virtual machines and responds automatically by adapting network services, according to established policies.
- Support massive scale and hybrid models – The Nuage Networks VSP seamlessly connects data centers and hybrid clouds with existing Layer 2 Ethernet or Layer 3 IP VPNs. Its distributed policy-based approach separates compute and networking technologies to allow multiple virtualization platforms to interoperate over a single network and optimizes the data center network by separating service definition from service instantiation.

Alcatel-Lucent has implemented data center virtualization technologies, such as network virtualization overlay (NVO) and virtual extensible LAN (VXLAN) in the Nuage Networks VSP and the 7750 SR. VXLAN is the de-facto overlay data plane standard for data center networking. It encapsulates Ethernet in IP, can be routed by IP and can be terminated on computer infrastructure or network equipment. The underlay network may be any IP network that uses existing routing, resiliency and load balancing mechanisms. Overlays can be viewed as a tunnel between two end points within the data center. They provide a number of benefits, including VPNs for multi-tenancy, network virtualization for location independence of resources within the data center, improved resource allocation and protection from topology or technology changes.

CASE STUDY: NUAGE SDN DEPLOYED IN A LARGE US BANK
- 50% reduction in operational expenses
- 10x improvement in turn-up response time with a reduction in configuration errors
- 40% increase in asset utilization and flexibility

Figure 5. Open programmable, automated and seamless DCI and cloud using Nuage Networks and the Alcatel-Lucent 7750 SR
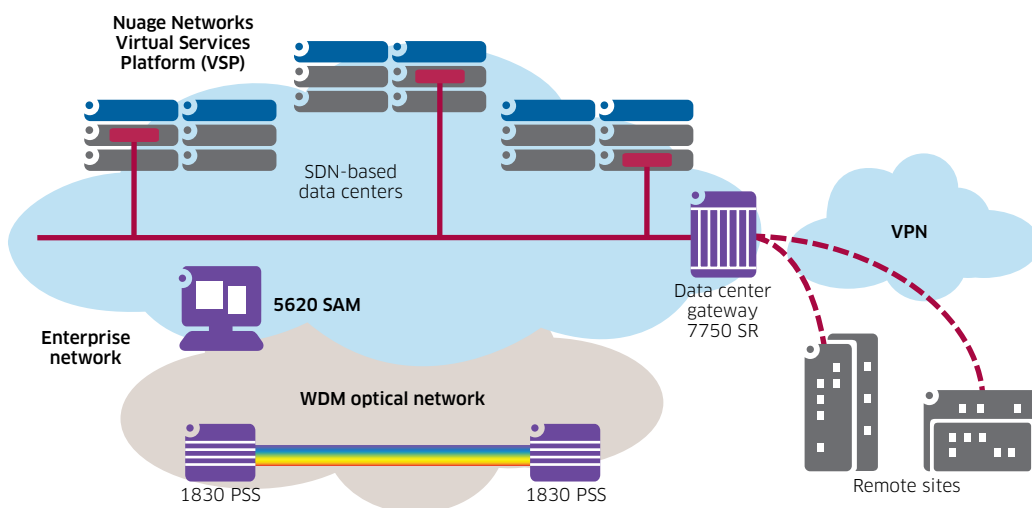
Alcatel-Lucent has combined NVO and VXLAN with emerging technologies, such as Ethernet VPN (EVPN) in the SR-OS software to enable a data center gateway function on the 7750 SR, as shown in Figure 6. EVPN provides an overlay control plane and is based on well-established MPLS and BGP routing protocols and operational experience used in service provider networks. It also includes some improvements over existing techniques, such as Virtual Private LAN Service (VPLS) used to deliver Ethernet LAN services over MPLS. When combined with VXLAN as the overlay data plane, E-VPN enables data center virtualization to be extended across the WAN between multiple data centers.

The data center gateway capabilities enable the 7750 SR to connect virtualized, cloud-based data centers over the WAN. By using these capabilities with the Ethernet and IP VPN capabilities of the 7750 SR, large enterprises can simultaneously and securely connect multiple virtualized, cloud-based data centers with remote sites in the private enterprise WAN, as well as with Internet-connected sites and the outside world. As a result, cloud bursting and hybrid cloud services are made possible in a highly dynamic and robust manner that is an extension of the existing enterprise wide area data services.

These solutions build on expertise that Alcatel-Lucent has learned from:
- Building very large IP/MPLS networks – In scaling IP networks, intelligence is pushed to the network edges. This same approach is used to enable a simple and cost-effective core datacenter network, consistent with the manner in which IP technologies have successfully scaled to date. The approach decouples network services from the infrastructure and enables parallel innovation in each domain.
- Designing mobile networks that have been optimized for massive subscriber scale – This yields a policy-driven auto-instantiation model for the datacenter network that minimizes costs and delays. The new model significantly increases the efficiency of delivering cloud services.
- Abstracting network capabilities into IT and business logic terminology – Applying the first two design principles fully virtualizes and automates any datacenter network infrastructure, transforming it into a reflexive environment that instantaneously establishes the network services required to deliver policy-driven cloud applications.

Using SDN to optimize the datacenter network enables it to be open and programmable. Network services within and between data centers are defined from an abstraction of network resources, and implementation remains independent of the underlying server or compute virtualization environment and data center network hardware.

Built from the ground up for the IT world of development and operations, the Alcatel-Lucent solution frees large enterprises to migrate to the most efficient models of application delivery without any compromise in security or compliance. A rich policy-based framework allows fine-grain control of access mechanisms that directly match the existing security and operational models of large enterprises, and scales to meet the future needs of large enterprise data center environments.

SUMMARY

Large enterprises need to consider new approaches to meet current and future DCI needs because of market trends such as the rapid gains in data center efficiency, the emergence of mega data centers, the impact of cloud computing, the virtualization of data center architecture and software-defined networking.

Alcatel-Lucent DCI solutions help large enterprises de-risk the provisioning of data center interconnect and include high performance, low latency, secure optical WDM solutions for synchronous applications, as well as IP/MPLS solutions that provide high performance, multi-site data center interconnect with advanced QoS and traffic engineering for asynchronous applications. Alcatel-Lucent data center network virtualization and software-defined networking solutions deliver unrestricted data center networking within the data center and across the WAN to greatly simplify operations, reduce costs and increase agility.

For more information about Alcatel-Lucent products and solutions for DCI, please see:

www.alcatel-lucent.com/products#data-center

www.alcatel-lucent.com/solutions/data-center-connect

ACRONYMS

CE	Carrier Ethernet
DCI	Data Center Interconnect
DDoS	Distributed Denial of Service
DWDM	Dense Wave Division Multiplexing
EVPN	Ethernet virtual private network
HPC	High-performance computing
LAN	Local Area Network
NAS	Network Attached Storage
NVO	Network Virtual Overlay
MEF	Metro Ethernet Forum
MPLS	Multi-Protocol Label Switching
QoS	Quality of Service
SAN	Storage Area Network
SDN	Software-Defined Networking
T-ROADM	Tunable-Reconfigurable Optical Add-Drop Multiplexing
VPLS	Virtual Private LAN Service
VPN	Virtual Private Network
VSP	Virtualized Services Platform
VXLAN	Virtual Extensible LAN
WDM	Wave Division Multiplexing

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