CLOUD-OPTIMIZED METRO NETWORKS

MOVING THE METRO FORWARD WITH AGILE, SCALABLE AND EFFICIENT NETWORKS

APPLICATION NOTE

Alcatel·Lucent

ABSTRACT

Metro networks are about to undergo significant transformations, driven by the continuing growth of residential, mobile, business and cloud services. The evolution to cloud services gives operators an opportunity to deliver whole new categories of services. It also calls for a fresh look at existing networks. This application note reviews the unfolding dynamics within metro networks and explains how the Alcatel-Lucent Cloud-Optimized Metro solution helps service providers implement agile, scalable and efficient metro networks that enable high performance cloud-optimized Carrier Ethernet and IP services.

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EXECUTIVE SUMMARY

Metro networks are on the cusp of significant transformation. A recent Bell Labs study forecasts total metro traffic will increase 560% by 2017, largely driven by IP video and the increasing adoption of cloud/data center services and applications. Cloud services in particular will have a significant impact on how Carrier Ethernet and IP services are delivered in the future. Service providers need to adapt and transform their metro networks to enable differentiated service offerings and maximize the use of existing network assets. Alcatel-Lucent is applying its expertise in the IP Routing, Optical Transport and Service Management domains to offer service providers an evolutionary path to an enhanced multi-layer network that leverages Software-Defined Network (SDN) technologies. The Alcatel-Lucent Cloud-Optimized Metro solution enables agile, scalable and efficient delivery of application-driven, on-demand cloud services.

MARKET TRENDS AND THEIR IMPACT ON METRO NETWORKS

Traffic in metro networks is poised for unprecedented growth. A recent Alcatel-Lucent Bell Labs Metro Network Traffic Growth Study [1] estimates, "Total metro traffic will increase 560% by 2017."

IP video and data center (DC)/cloud traffic are the largest drivers for growth. According to the Metro Network Traffic Growth Study:

- Metro video traffic (including pay TV and Internet video) will increase 720%
- Metro cloud and DC traffic will increase 440% by 2017[1]

Combined, video and cloud/data center traffic are the key drivers to an overall forecast growth of 560 percent increase in traffic in the metro by 2017.

Service requirements are evolving

The metro network enables delivery of Carrier Ethernet (CE) and IP-based services. CE has gained rapid adoption within metro networks, enabling retail and wholesale Ethernet services as well as aggregation/transport functions for residential and mobile business IP services. The CE services market continues to grow significantly.

Infonetics projects retail and wholesale Carrier Ethernet service revenue will exceed US $56B by 2017.

Infonetics, Ethernet and IP MPLS VPN Services Forecast, June 2013

As services get commoditized, service differentiation is becoming crucial in order to maintain competitive advantage. According to a recent Heavy Reading report,[2] in the near term service providers will increasingly look to differentiate by emphasizing "Telco 2.0" service capabilities such as real-time performance visibility, dynamic bandwidth and network-based application awareness. Service differentiation is key for operators and metro networks need to support attributes that enable this differentiation. Metro networks need to evolve to support new cloud service requirements. The cloud service delivery model calls for dynamic, on-demand and rapid connectivity. For a metro network operator, this means that it must be possible for resources within the metro network to be requested or released based on changing application needs. This calls for a cloud-optimized carrier network that can address the dynamic nature of distributed clouds.

1 Growth numbers assume 20% yearly growth rate for the numbers of metros that have DCs deployed and a 60% increase (moderate growth) in the number of DCs deployed within the metro network by 2017.

2 Heavy Reading, *SDN CE 2.0 and Cloud converge*, March 2013.

Increase in network capacity and number of network nodes

Advances in ultra-broadband access are driving the need for higher capacity in aggregation networks. DSL vectoring and bonding, increased adoption of PON access and the evolution to LTE/LTE-Advanced in the mobile access space are resulting in increasing on-ramp speeds. This in turn drives the need for higher capacity in the metro aggregation and transport network. End-user demand for pervasive connectivity, and mobile traffic growth in particular, are driving up the number of access nodes (DSLAM, PON, mobile base stations, small cells, and Carrier Wi-Fi® access points) deployed in service provider networks. This in turn is increasing the number of endpoints (nodes) and connections within the metro aggregation network. Service providers anticipate a need for the network to support tens and in some cases hundreds of thousands of nodes.

More complex network and service management

The increasing number of endpoints and connections in metro networks makes provisioning complex and cumbersome. Operators are looking at solutions that reduce complexity and offer simplified end-to-end manageability. The service management capability must extend to cross-domain features within the IP and Optics domains. In addition, service management in multi-vendor deployments is a key area of focus for service providers.

Evolution to converged packet-optimized networks

To ensure their long-term economic health, service providers can no longer afford to support multiple infrastructures dedicated to specific customer types. There is a growing trend toward service convergence on a common high-performance CE/MPLS network.

Service providers are implementing next-generation technologies for increased efficiency and cost savings. They are migrating legacy transport systems to new optical transport systems supporting OTN, WDM and CE services. Demand for more bandwidth is driving the need for higher speed wavelengths with better price-to-performance ratios. The widespread adoption of 100 Gb/s in turn drives an increased use of OTN to efficiently fill these higher capacity pipes.

71% of survey respondents whose companies offer mobile backhaul service said that they now run these services on the same network as their Ethernet business services.

Heavy Reading, Ethernet & SDN Executive Council State-of-the-Industry Survey Report, 2Q13

More traffic staying within the metro network

As the demand for video content increases, video caching is now being implemented within metro networks, moving content caching deeper into the network. This approach ensures a superior QoE as most popular content is now sourced from within the metro network and not uniquely from a national caching location. The increasing importance of DCs for cloud services and, moving forward, advanced networking functions like Network Functions Virtualization (NFV) will result in significant proliferation of DCs within metro networks.

Due to the increased concentration of traffic sources within the metro network, more bandwidth will now stay local within the metro network. Until recently, metro traffic had a north-south flow from a content source to the end user with content sources (managed or over-the-top) typically located at a national central location and accessed via the backbone network. These north-south flows now see a shift in the location of content sources and end-user destinations: content sources will be concentrated within the metro network and end users are now increasingly accessing content via fixed and mobile devices. Traffic will also experience increasing east-west flows for traffic flows from DC to DC. These shifts in traffic flows require network architectures that deliver scale and versatility to meet current and future needs.

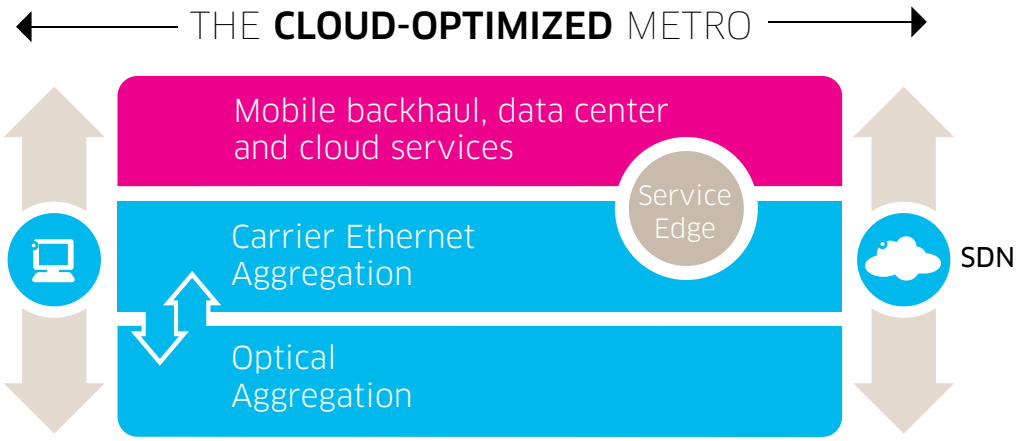
By 2017, 75% of total metro traffic will be terminated within the metro network and 25% of traffic will traverse the backbone network.

Alcatel-Lucent, Bell Labs Metro Network Traffic Growth Study, October 2013

ALCATEL-LUCENT CLOUD-OPTIMIZED METRO SOLUTION

The Alcatel-Lucent Cloud-Optimized Metro solution framework is shown in Figure 1. Around the world, service providers are moving the metro and their business forward with innovative, cost-effective solutions from Alcatel-Lucent. Alcatel-Lucent solutions provide the agility, scale and efficiency service providers need to optimize and modernize the metro aggregation network.

Figure 1. Alcatel-Lucent Cloud-Optimized Metro solution framework



The metro must evolve

Advances in ultra-broadband access, combined with growing video traffic, are driving the need for higher capacity in the metro. DC proliferation and growing video traffic are behind a fundamental shift both in the way metro networks are architected, and how existing and future services are delivered.

The increasing number and importance of DCs is pushing CE and IP services to become more aligned to cloud services requirements. CE and IP services must be more dynamic and automated to support on-demand, instantaneous network connectivity.

The cloud-optimized metro network

Service providers worldwide have partnered with Alcatel-Lucent to modernize their metro networks to deliver differentiated CE and IP services. Alcatel-Lucent offers an industry-leading CE and optical aggregation portfolio. According to Heavy Reading[3], Alcatel-Lucent is the number 2 vendor in the IP/MPLS and CE segment with a market share of 25%. Alcatel-Lucent is the number 2 vendor[4] in IP Edge routing worldwide. The metro framework supports a Service Edge function for enabling IP services as well as differentiation for Carrier Ethernet services (e.g. Network based Application Assurance and DDOS Threat Mitigation Services). In a recent Infonetics[5] survey, service providers rated Alcatel-Lucent the number one optical equipment vendor for service and support and the number two optical and packet-optical equipment vendor overall.

3 Heavy Reading: Carrier Ethernet Switch/Router Quarterly Market Tracker - March 2013
4 As determined by all leading Industry analysts tracking the IP Edge router market.
5 Infonetics Research, *Optical Equipment Vendor Leadership – Global Service Provider Survey*, Sept 2013.

The cloud-optimized metro network supports an industry-leading service management system which manages the IP and Optics domains of the metro network. According to an Analysis Mason report[6], "The 5620 SAM (Service Aware Manager) was designed to be a multi-domain (mobile, business services and residential broadband) NMS, which can manage network technologies from the core to the access network such as optical transport and access, IP-MPLS, Carrier Ethernet and mobile Packet Core."

Cloud and DC services will have a significant impact on metro networks going forward. The dynamic nature of emerging cloud services requires an agile metro network that can create and instantiate cloud services and applications faster and on demand. The Communications Service Provider's (CSP's) infrastructure must support mechanisms for end users to request and program policies and instantiate rapid on-demand network connectivity based on these policy definitions. Software-defined networking (SDN) principles are successfully being applied within DC networks to make intra-DC connectivity instantaneous and boundary-less. The metro network needs to evolve and inherit attributes of existing DC networks where network connections are initiated in seconds compared to hours or days in most WANs today.

Alcatel-Lucent is applying its expertise in the IP Routing, Optical Transport and Service Management domains and working towards offering service providers an evolutionary path to an enhanced multi-layer network that leverages SDN technologies. The enhanced network will support existing and SDN-enabled services.

For operators to stay ahead of the bandwidth curve, the metro network hierarchy needs to scale to support speeds of 10 Gb/s, 40 Gb/s, 100 Gb/s and beyond. Alcatel-Lucent offers advanced platforms, as well as innovative architectures and features to enable end-to-end scalability of metro networks. These include:

- Industry-leading, highly scalable CE, IP and optical aggregation platforms
- A flexible metro core architecture, supporting massive scalability as well as convergence for architecture simplification
- Features like Seamless MPLS and MPLS TP

Alcatel-Lucent offers service providers new technologies and approaches that improve the efficiency of their metro networks. CE technology from IP routing platforms is leveraged to enable CE services on the optics platform. Innovations in end-to-end service management, augmented with SDN technologies, will help reduce complexity and cost while optimizing the use of existing network resources.

AGILE, ON-DEMAND SERVICES

The metro network enables delivery of CE and IP services, which together create the foundation for the delivery of agile, on-demand, high performance services. The cloud-optimized metro network combines existing CE and IP connectivity services with cloud/DC technologies and SDN to deliver high performance, on-demand cloud related services and applications.

6 Analysis Mason: Return on investment of the Alcatel-Lucent 5620 SAM - 2011

Carrier Ethernet 2.0 and IP services

CE and IP services leverage foundational building blocks that support diverse access options, low latency, multiple QoS levels, synchronization, end-to-end OAM and service provisioning capabilities. The CE services layer is responsible for all aspects associated with CE service delivery. IP-based services are enabled via the IP service edge. In some deployment scenarios the service edge function may be extended into the metro network (for example, with a distributed residential Broadband Network Gateway platform in the metro).

The Metro Ethernet Forum (MEF) is the defining body for CE [2]. The MEF's Carrier Ethernet 2.0 (CE 2.0) framework is the current baseline for service providers deploying CE services. The Alcatel-Lucent 7750 Service Router (SR) and 7210 Service Access Switch (SAS) product portfolios and 1830 Photonic Service Switch (PSS) platforms are CE 2.0 certified [3], allowing service providers to deliver standardized CE services.

The most important service features for end users include end-to-end performance SLAs, service bundling (offering a combination of CE services along with IP-VPN and/or Internet access services) support for multiple QoS classes and web service portals. Alcatel-Lucent offers a service portal solution which provides self-service capabilities and provides end users with network utilization and real-time performance metrics as well as support for features like Bandwidth on Demand and Proactive notification and actions upon breach of SLA thresholds.

Differentiated services

Operators who are concerned with a commoditized market are looking at options to help retain existing customers while winning new ones. Service providers can take advantage of several unique Alcatel-Lucent IP portfolio innovations to help differentiate their CE 2.0 and IP service offerings. For example, basic connectivity services can be enhanced with application awareness and security capabilities, as part of a managed service offering. Alcatel-Lucent offers integrated Application Assurance and Distributed Denial of Service threat mitigation solutions (sometimes referred to as clean pipes) for Internet access. These solutions do not require dedicated CPEs/appliances.

The cloud services opportunity

Many CSPs are enhancing their position in the cloud services market by acquiring established cloud infrastructure assets/providers. The CSPs' biggest assets are their metro and backbone networks. CSP networks already support several attributes that are crucial for the delivery of cloud services. These include:

- Proven network reach
- Diverse points of presence
- Reliability, security, and proven SLAs
- A trusted relationship with the end customer

Interconnection between virtual machines within a DC can be set up dynamically, on demand and within seconds, with little or no operator involvement. Enterprises and Data Center Providers will demand the same level of agility when cloud DCs and end users are interconnected across the metro and WAN.

To ensure profitable growth, cloud services must become simpler to turn-up and consume. This calls for a cloud-optimized carrier network that can address the dynamic nature of distributed clouds. Alcatel-Lucent is leveraging its expertise in IP, Optics and Service Management domains and working towards implementing a complete SDN-enabled solution so service providers can prepare their metro/WAN infrastructure for delivery of cloud-optimized services [4].

The SDN framework can enable new cloud-optimized services or enhance service delivery models for existing services. For example the Bandwidth on Demand service can benefit from SDN's policy management and resource management functions [4]. Table 1 lists potential cloud services or application use cases that will benefit from a multi-layer SDN-enabled metro/WAN.

Table 1

CLOUD SERVICE OR APPLICATION USE CASE	BENEFIT TO ENTERPRISE OR DC PROVIDER
Flexible and dynamic DC connectivity	• Can request and instantiate dynamic connectivity between DCs as well as between DCs and end users • Supports enterprise or DC provider policies; these may include network, security and service policies
Cloud bursting service	• Provides need-driven (bandwidth-on-demand) connectivity to boost an existing private or public cloud service with support for policies and resource aware connectivity
Advanced services enabled via service chain creation over metro/WAN	• Accelerates adoption of advanced services and minimizes operational costs • Reduces the provisioning time for the creation of service chains for cloud services that require stitching of value-added functions like firewall, NAT and web filtering

Today's metro and WAN services are optimized for the relatively static and predictable task of aggregating and forwarding traffic from remote enterprise sites/users to centralized DCs. Network provisioning is handled with complex IT/OSS systems with manual provisioning processes that are based on command-line interfaces or script files. SDN-enabled cloud-optimized services will be instantiated in seconds or minutes instead of days or weeks in the present mode of operation.

With the new framework, services and applications are defined using policies that can be rapidly instantiated — on a mass scale — using customer, application or network events as triggers, much in the way that cellular subscribers initiate connections today. Operators can define policies for dynamic connection and dynamic bandwidth on demand, including overbooking.

To ensure services don't run out of bandwidth or start drifting from their pre-defined QoS attributes, network operators will have to revisit the network allocation and engineering decisions they make on a more frequent basis. Support for global resource visibility and control within the underlying IP routing and transport layers is critical to ensure that services receive the requested service attributes (bandwidth, latency, QoS) consistently and on demand.

For Enterprises and Cloud service providers (including CSP's who will offer Cloud infrastructure services) who wish to implement SDN within their DC networks, Alcatel-Lucent currently offers a solution with Nuage Networks. Nuage Networks enables virtualized and automated intra-DC connectivity as well as capabilities to support inter DC and DC to end user connectivity.

SCALABLE AND EFFICIENT METRO NETWORKS

This section looks at the building blocks that contribute to the cloud-optimized metro network's scalability and efficiency:

- IP metro core
- Fixed and mobile network convergence
- Seamless MPLS
- IP-optical integration
- Converged IP/optical service management
- SDN-enabled network efficiency

IP metro core

Alcatel-Lucent has introduced the innovative concept of an IP "metro core" to meet the increasing demand for scale and to address shifting traffic flows within the metro network [5].

The metro core acts as a regional backbone, providing connectivity between the various access and aggregation networks within a given metropolitan area. It switches intra-metro traffic and connects into a national backbone (or core) network to enable connectivity with other metro, regional and national networks. The metro core may also serve as the termination point for metro DCs (for cloud services and applications like NFV). The primary function of the metro core is to support high speed (10 Gb/s, 40 Gb/s, and 100 Gb/s) and high density (multiple terabits capacity) aggregation. However, the role of an IP metro core node may be extended beyond pure aggregation functions to support IP/MPLS LSR, IP core routing and IP infrastructure and service features (IP VPN, Internet Services, VLL and VPLS).

Fixed and mobile network convergence

With business, residential and mobile services all making the transition to IP transport, the metro network is now ripe for consolidation and increased efficiency. TDM-based metro networks are being transitioned to packet-based networks. It is no longer economically feasible to support multiple customer-specific infrastructures. Many operators have converged their separate service networks to a single IP/MPLS network for business, residential and mobile services.

This is indicative of the growing trend towards extending the role of MPLS within service provider networks. Service providers are using MPLS to deliver scalable end-to-end networks (with enhancements like Seamless MPLS) while supporting delivery of services.

In addition to convergence at the IP/MPLS layer, demand for more bandwidth is driving the need for higher speed wavelengths with better price-to-performance ratios. This is, in turn, driving increased interest in and adoption of OTN grooming and switching solutions. The IP and optical layers and how they interact plays a critical role in the convergence of fixed and mobile networks.

In a recent survey, more than 75% of respondents said that they use or intend to use MPLS in the access network to support business and wholesale services.

Heavy Reading, Ethernet & SDN Executive Council State-of-Industry Survey Report, 2Q13

Seamless MPLS

Seamless MPLS helps service provider's scale their existing MPLS networks to support end-to-end architectures with thousands of nodes. MPLS deployments have been extended to the metro access network to support mobile backhaul for evolution to LTE, as well as business and residential service deployments. MPLS is now deployed end-to-end from access to aggregation to the IP core layers of the network.

MPLS currently offers several features like LDP extensions for inter-area LSPs, intra- and inter-area RSVP-TE, LDPoRSVP and pseudowire switching (multi-segment pseudowire) to support end-to-end MPLS services. However, these features do not completely address the flexibility, scalability, resiliency and manageability required for end-to-end MPLS networks.

Seamless MPLS (an IETF Working Group initiative) is a preferred alternative, as it provides maximum scalability, flexibility, ease of provisioning and maintenance and can scale to support over 100,000 nodes. Several service providers have already implemented Seamless MPLS within their networks. Many operators are now evaluating Seamless MPLS for mobile backhaul architectures and for evolution to converged (intra-autonomous system or inter-autonomous system) MPLS architectures. Alcatel-Lucent offers a comprehensive and industry validated feature set that enables service providers to implement end-to-end Seamless MPLS network architectures.

CDN and video caching within the metro network

The Bell Labs metro traffic growth study forecasts that video traffic will increase 720% by 2017. Implementing Content Delivery Networks (CDNs) is no longer an exception and instead is becoming the norm with more and more content being cached closer to the end user and within the metro network. The 7810 Velocix Content Delivery Network enables network service providers to build their own CDN. The content delivery network caches the most popular content close to end users. When the same content is requested by multiple end users it is served from this cache, which reduces bandwidth consumption within the network through to the cache. Alcatel-Lucent offers multiple options to optimize bandwidth usage in the service providers' network and also delivers a better quality of experience to end users: service providers can cache the content in agreement with content providers (retail and wholesale, typically for pay TV services); or, they can cache content without any commercial agreement with content providers (transparent caching for OTT services).

IP/optical integration

Alcatel-Lucent has a very large installed base of customers that deploy both IP routing and optical transport platforms. Alcatel-Lucent has leveraged its expertise in both IP and Optics domains to deliver integration of best-of-breed functions across the IP routing and optical transport portfolios.

- The same CE technology is leveraged across both IP and optical platforms. CE technology (hardware and Service Router Operating System software) from the IP routing platforms is leveraged to offer Integrated Packet Transport blades on the 1830 PSS platform. This enables proven CE solutions with a common operations and service management model across both IP and Optics domains.
- The IP routing portfolio supports IPoWDM functions via 10GE, 40GE and 100GE tunable optical line cards. This reduces CAPEX as it eliminates the need for external transponders. Alcatel-Lucent Wavelength Tracker technology enables proactive fault tracing for individual wavelength channels across IP and Optics domains.

- The Alcatel-Lucent 1830 Versatile WDM Modules (VWM) are passive, compact coarse and dense WDM “add-on” shelves that provide cost-effective scalability and CWDM to systems lacking WDM functionality. The 1830 VWM can be managed via a dedicated optical management interface or via a USB interface on the IP routing platforms.
- The Alcatel-Lucent 7705 Service Aggregation Router (SAR) supports integrated OADM adapter cards and modules for network operators who may prefer an integrated approach for addressing WDM deployment.
- The Alcatel-Lucent IP routers can be integrated with an 1830 PSS-based Optical Extension Shelf (OES) to support a consistent operational model with tighter integration between optical and routing layers. This approach optimizes high speed interface density on IP routers by supporting optical transceivers in the OES. The implementation of GMPLS UNI functions across the IP and optical layers will enable dynamic connection establishment across layers while also improving network protection and providing more efficient use of resources across the IP and Optics domains.

Converged IP/optical service management

The metro network needs to support tens and in some cases hundreds of thousands of nodes and connections. Metro networks need to support end-to-end connection provisioning, resiliency and rapid recovery from failures. In addition, service providers are taking steps to integrate the IP and optical layers of their network infrastructure from metro, to edge, to core. Alcatel-Lucent provides a single unified service management platform — the Alcatel-Lucent 5620 Service Aware Manager (SAM) — to deliver the flexibility needed to provision and maintain the IP and Optics domains together or separately. Converged IP/optical management provides many advantages:

- Fast and easy network provisioning and multi-vendor scripting of workflows reduce risk of error and speed network deployment time.
- Faults are co-related, helping to pinpoint whether the problem resides in the IP or optical layer and its root cause. This simplifies troubleshooting and isolates impairments before services are impacted.
- Service degradation can be proactively prevented through end-to-end power control, monitoring, tracing and fault localization for individual wavelength channels (enabled by Alcatel-Lucent Wavelength Tracker technology).
- Accelerated setup is available for integrated IP/optical performance and SLA monitoring, with service-aware diagnostics that validate end-to-end data services and IP/optical paths.
- User profiles can be enabled based on an operator’s responsibilities, to support secure collaboration between IP and optical network engineers.

Visibility across both the IP and Optics domains is crucial for today’s metro networks and optimizes network operations and the efficiency of overall network turn-up and troubleshooting.

SDN-enabled network efficiency

In addition to enabling agile service delivery, the Alcatel-Lucent multi-layer SDN framework [4] will support multi-layer visibility and control for improved network efficiency. As traffic patterns start to change and become less static, service providers will have to manage the increased complexity this places on their networks. Network operations will no longer be able to ensure service availability and quality with planning cycles spread months apart.

The process of mapping customer service requests to IP/optical transport connections will need to ensure that the best path is selected, and that the service provider's IP/optical resources are being used in the most efficient manner. To make these decisions in real time, service providers require instant, global visibility of all network resources and topologies — from IP/MPLS to the optical layers — along with the capability to provision these resources on demand. This is not possible today given the complexity involved in gathering, correlating and analyzing information, and the difficulty in coordinating provisioning across many layer-specific and/or vendor-specific systems. Instead, operators are assigning ever-increasing amounts of bandwidth to accommodate the growing peak-to-mean gap. Alcatel-Lucent is leveraging its expertise in the IP, Optics and Service Management domains to provide a cohesive solution across the IP routing and transport layers. This is crucial as both layers need to work together to provide optimum resource utilization.

The multi-layer SDN framework will provide a policy-based approach to track SLAs and automate traffic and network engineering. Transport connections, metrics and bandwidth can be dynamically adjusted in the range between minutes and weeks. This will help enable new network efficiency use cases, such as:

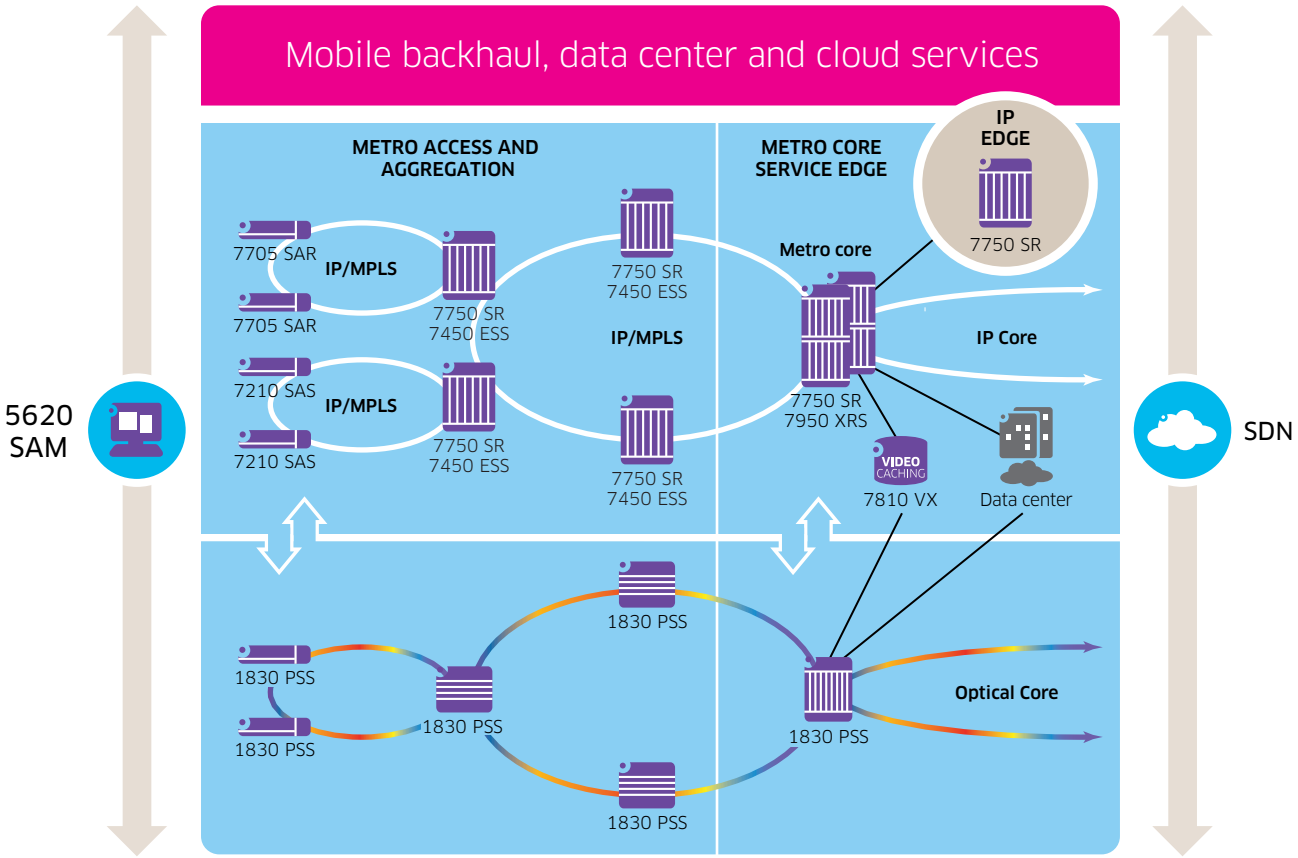
- **Traffic Steering**, which provides a means to rank network resources in real-time based on multiple factors and then steer traffic to a preferred resource endpoint. Factors can include network load, resource load and availability; location; network delay; link capacity and peering point congestion.
- **Network Slicing**, which allows operators to create and manage multi-layer, traffic-engineered infrastructure service planes.

These use cases may be implemented for internal network optimization or potentially enable new service options.

ALCATEL-LUCENT CLOUD-OPTIMIZED METRO SOLUTION – PRODUCT SUMMARY

Figure 2 depicts the Alcatel-Lucent Cloud-Optimized Metro solution reference architecture. Alcatel-Lucent offers a comprehensive portfolio of IP and optical platforms that support CE and IP services, Ethernet aggregation and transport. The Ethernet and optical aggregation solution includes IP routing and optical transport platforms that support speeds up to 100 Gb/s and beyond.

Figure 2. Alcatel-Lucent Cloud-Optimized Metro solution reference architecture



Alcatel-Lucent leverages its expertise in the IP and Optics domains to integrate best-of-breed functions across domains, enabling integrated and proven CE solutions. The IP and Optics domains are managed by a single converged service management solution. This approach optimizes efficiency in the integrated network, while making it possible to separate each domain to be consistent with the existing operational infrastructure and management practices.

CONCLUSION

Metro networks are on the cusp of significant transformation. Service providers need to scale, optimize and modernize their networks for the delivery of innovative CE, IP and emerging cloud services. Alcatel-Lucent is a market leader in the CE and IP services segment with complete IP routing and optical transport portfolios, both managed by a single service management system (Alcatel-Lucent 5620 SAM).

Alcatel-Lucent offers several innovative and unique features that make the metro network more agile, scalable and efficient, enabling the delivery of cloud-optimized services. The impact and role of SDN within metro networks is a critical area for service providers. Alcatel-Lucent is in a unique position to offer service providers a true multi-layer SDN framework. The framework supports both existing services as well as the new services enabled by SDN. It also supports cross-domain co-relation and optimization.

By partnering with Alcatel-Lucent, operators can stay ahead of the bandwidth curve, get more out of existing network assets, drive revenue by delivering new categories of services, and simplify network operations and service management within their metro networks.

REFERENCES

All of the referenced papers are available from the Alcatel-Lucent Cloud-Optimized Metro solution web page.

[1] Alcatel-Lucent *Bell Labs Metro Network Traffic Growth: An Architecture Impact Study*, white paper, December 2013.

[2] Metro Ethernet Forum's Carrier Ethernet 2.0 standard: http://metroethernetforum.org/carrier-ethernet/carrier-ethernet-and-ce-2-0

[3] *Alcatel-Lucent and MEF Carrier Ethernet 2.0*, application brief, December 2013.

[4] Alcatel-Lucent *The Cloud-Optimized MAN and WAN: Leveraging a multi-layer SDN framework to deliver scalable and agile cloud services*, white paper, December 2013.

[5] Alcatel-Lucent *Upscaling the Metro: Deploying the 7950 XRS in the metro core*, application note, December 2013.

FURTHER READING

Alcatel-Lucent IP-Core Routing solution
Alcatel-Lucent IP-Edge Routing solution
Alcatel-Lucent Cloud-Optimized Metro solution
Alcatel-Lucent Agile Optical Networking solution
Converged IP/Optical Network Management: A service aware approach

ACRONYMS

1830 PSS	Alcatel-Lucent 1830 Photonic Service Switch
1830 VWM	Alcatel-Lucent 1830 Versatile WDM Module
5620 SAM	Alcatel-Lucent 5620 Service Aware Manager
7210 SAS	Alcatel-Lucent 7210 Service Access Switch
7705 SAR	Alcatel-Lucent 7705 Service Aggregation Router
7750 SR	Alcatel-Lucent 7750 Service Router
BGP	Border Gateway Protocol
CAPEX	Capital expenses
CE	Carrier Ethernet
CSP	Communications Service Providers
DC	Data center
DCP	Data Center Provider
DDOS	Distributed Denial of Service
DSL	Digital Subscriber Line
DSLAM	DSL access multiplexer
FIB	Forwarding information base
GMPLS	Generalized Multiprotocol Label Switching
HA	High availability
IETF	Internet Engineering Task Force
IS-IS	Intermediate system to intermediate system
LDP	Label Distribution Protocol
LDPoRSVP	Label Distribution Protocol over Resource Reservation Protocol
LSP	Label-Switched Path
LSR	Label Switch Router
LTE	Long-Term Evolution
NAT	Network Address Translation
NFV	Network Functions Virtualization
NMS	Network Management System
OADM	Optical Add-Drop Muliplexer
OAM	Operations, Administration and Maintenance
OES	Optical Extension Shelf
OSPF	Open Shortest Path First
OTN	Optical Transport Network
PIM	Protocol Independent Multicast
PON	Passive Optical Network
QoE	Quality of experience
QoS	Quality of service
RSVP	Resource Reservation Protocol
RSVP-TE	Resource Reservation Protocol – Traffic Engineering
SDN	Software-Defined Network
SLA	Service level agreement
UNI	User-Network Interface
VLL	Virtual Leased Line
VPN	Virtual Private Network

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