The Next-Generation LSR

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Key Takeaways

- Disintermediation is disrupting traditional Internet models.
- Coherent technology has dramatically increased the value of converging IP and optics.
- Content providers' networks have similar but differing requirements from those of service providers.
- The next-generation LSR will not replace core routers; instead, as a "true MPLS switch" it will complement them.
- The next-generation LSR can be deployed as an MPLS switch or as a packet optical transport platform.
- Spending on optical equipment by content providers is reaching into the billions according to ACG Research.

EXECUTIVE SUMMARY

With the successful penetration of smart phones and tablets, ubiquitous access to information is no longer limited to standalone and fixed devices. Thirst for more bandwidth continues to grow exponentially, and traditional service providers have approached a fork in the road. They can either become a transport utility or a value-added service provider.

While service providers work on developing service opportunities, they have realized that content delivery has morphed, creating a new infrastructure of interconnected content provider networks that are shifting traditional service providers to the side and establishing direct connections between consumers and content. This disintermediation is disrupting traditional economic models in the Internet and new players are beginning to define and reshape the networks.

This paper examines how content providers' requirements differ from service providers' requirements; how a next-generation label switched router can provide benefits for both types of networks; and how new optical technologies have enabled a breakthrough and paradigm shift that now enable and significantly increase the value of converging packet and optical technologies.

TABLE OF CONTENTS

DRIVERS FOR A NEXT-GENERATION LSR

What are the drivers for a next-generation label switched router (LSR)? For the past year, content and service providers have been requesting a "stripped down core router," to which we refer as the next-generation LSR, because the main function of this router is to switch MPLS labels. However, to reach new cost points this product must be purpose built from scratch and include a wide-range of requirements and functionality, from a simple next-generation LSR to one that includes integrated optics. Whether the product has integrated optics or not, the next-generation LSR must meet several requirements.

> *"We define the next-generation LSR as a purpose-built, lean, core optimized platform, which means it contains basic MPLS forwarding and is not burdened with core router feature sets that are not required for us."*
>
> Content Provider

1) Replace border/core routers with simple next-generation LSR switches in content and service providers' networks. Today, most core routers are peering with thousands of sites, but in other locations, they are simply being used as an LSR where much of the functionality of the core route is unused. Service and content providers require an intelligent and massively scalable Layer 2+ switch that needs only to terminate with the next router it encounters and forward packets, reducing the need for extensive processing and maintenance of Internet look-up tables, which accounts for the majority of the core router cost. Content providers are the primary requestors of this first application, but some service providers in Europe are also very interested in deploying a next-generation LSR.

2) The next application for the next-generation LSR is to connect the internal MPLS network within the data center with the infrastructure that interconnects the national data centers, thus creating a transparent any-to-any connectivity between and into the data centers.

3) The final application for the next-generation LSR is utilization as a packet optical transport (POT) system. Major Tier 1 service providers, such as Verizon, have clearly stated the need for a POT product in their LH-OTP RFI. For this application the next-generation LSR must have integrated optics (or be interconnected to a DWDM shelf to support long distances), and function as a packet optical transport system.

The POT system that uses the next-generation LSR architecture lowers the cost of routing by eliminating processing and memory requirements for Layer 3 functionality; integrating optics reduces transport costs because wavelengths can be generated directly from within the product. The next-generation LSR can and will fit into this application but requirements for content providers are different from those of service providers when integrated optics come into play.

Next-Generation LSR Requirements

The next-generation LSR has to meet massive density and scaling requirements. Service providers have indicated that the next-generation LSR varies from 1.2 terabits per bay (European providers) to up to 3 to 4 terabits per bay (North America providers). However, content providers prefer the higher density and are requesting double that density in the next year.

The next-generation LSR is primarily a Layer 2+ MPLS (and MPLS-TP) switch, but there is a "grey area" between the Layer 2+ and Layer 3 requirements; the LSR will need to terminate at core and edge routers and use RSVP signaling but will not require massive BGP peering or multicast feature sets.

Next-generation LSRs may initially be created with a switching fabric designed with off-the-shelf Broadcom chips (they are extremely high functioning, and it makes strategic business sense for vendors to shorten the time to revenue and not reinvent this chip set) and, mostly likely, with in-house ASICS on the client side to support sophisticated buffering that is required going into and out of the switch. Maximizing the input and output buffering are key requirements to ensure that individual flows are guaranteed access to bandwidth.

Network Infrastructure Requirements: How Content Providers Differ from Service Providers

The growing disparity between content and service providers' requirements is helping fuel demand for the next-generation LSR. While both providers are service oriented, their approach to network infrastructure is quite different.

Requirements for the Next-Generation LSR with Integrated Optics		
Requirement	**Service Providers**	**Content Providers**
Direction	Multidirectional	Point to point
Flexibility (ROADM)	Required	Not required
OTN switching	Required	Not required
Connectivity	Variation of bandwidth	Very fat pipes
Data centers	100–200 in North America	6 to 8 in North America
Carrier class requirements	NEBS, Osmine, 5 9s	4 to 5 9s
Fiber availability	Relatively available	Scarce for remote locations
Distances required	1200 to 1500 km	2500 km is sweet spot
MPLS	MPLS-TP required	MPLS only
Smooth upgrade	Required	Required
Technology	Advanced, cutting edge	"Simple gets into the network"

Table 1. Next-Generation LSR with Integrated Optics Requirements

Typical service providers have millions of customers and thousands of applications running on their networks, which require extensive quality of service and high-functionality routers. Content providers have fewer applications running on their networks but have extensive bandwidth demands, which are rapidly increasing.

> *"100G is the starting point for this product."*
>
> Content Provider

Content providers often use core routers with full IP functionality to interconnect all their data centers, which are primarily point-to-point connections. However, fewer data centers mean longer distances between data centers and, typically, fewer protection routes from which to choose. The average content provider has 5 to 10 mega data centers in North America, whereas Tier 1 service providers have over 100 to 200 data centers (and/or central office sites). With up to 200 data centers to interconnect, distances are shorter and protection and restoration somewhat simpler for service providers as there are more route opportunities.

Service providers require multipoint connectivity and significant add/drop switching at their central office/data center sites. For example, AT&T's IPTV and Verizon's FiOS networks provide extensive metropolitan and regional add/drop switching capability for video distribution as close to the customer as possible.

Content providers have smaller staffs to run the network than a typical service provider. While their staffs have grown in the past few years, they are still minute in comparison to those of most service providers.

Service providers deploy anywhere from OC-3 to 10G on more than half of their routes (the rest require upwards of 100G or multiple 100G links), whereas content providers require massive amounts of bandwidth (100G minimum per link) between data centers. *Because the bandwidth on content providers' networks has grown faster than on service providers' networks, content providers' spending has increased dramatically and is now approximately over $1 billion (2010).*[1] Clearly, the economics have shifted, indicating that more attention should be paid to the customer/provider portion of the optical market.

Google, the predominant content provider, has had smooth but significant increases in bandwidth this year; however, content providers such as Microsoft and Amazon have had "hockey stick" growth because of cutting-edge cloud services that require massive, new infrastructure. Even Akamai, while not a direct client of optical gear, is now launching 4 to 5 terabits of data mostly at 10G rates into the Internet.

[1] ACG Research

Service providers' networks are typically in every major city. Content providers' data centers are located in rural areas where fiber is scare and connectivity is challenging, requiring extended distances without regeneration. In some cases, content providers are redesigning their transport networks to look more like traditional satellite head ends where instead of multiple data centers they are considering reducing to two data centers and connecting locally from there. This proposed architecture is called "cow town" because the data centers reside in rural areas.

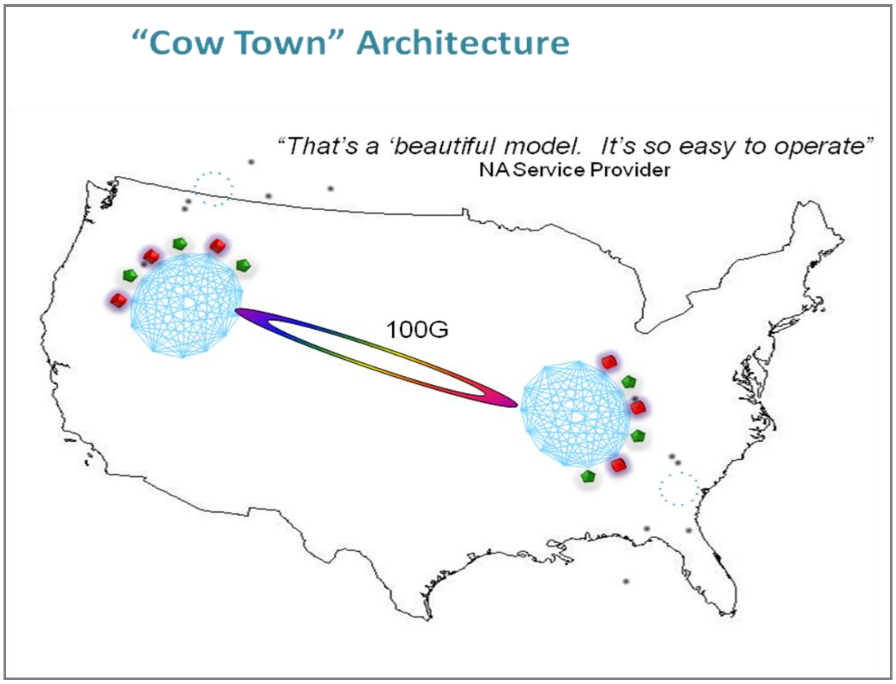

Figure 1.Cow Town Architecture

Connecting two major data centers with transport equipment is less expensive if latency is not an issue. If latency is an issue, a content provider will locate data centers closer to the customers but will still locate in rural areas to benefit from lower costs and power advantages. This architecture looks similar to service providers' architecture except that content providers' data centers are farther apart and require distances up to 2,500+ km without regeneration. Thus, capacity, reach, and cost become increasingly critical for content providers. These requirements are important to service providers, but the average distance between metropolitan areas is 1200 to 1500 km; where, today, standard regeneration is possible.

CONTENT PROVIDER DATA CENTERS: A MOVING TARGET

Vast improvements have been made in the data center where flattening of the intradata network has kept costs and complexity down. As data centers increase the numbers of servers, in some cases up to 100,000 servers per site, high bandwidth infrastructure has been deployed to scale operations, mostly at Layer 2 for lower cost, but more importantly, to scale applications across server clusters. As these architectures have improved, the network between the data centers has increasingly become the bottleneck. *That bottleneck can and will be solved by the next-generation LSR.* Within a data center, clusters of servers are typically aggregated and interconnected with very large switching matrices, similar to parallel supercomputers, and just like massively parallel supercomputers some level of routing is required. To a greater extent, large data centers have two border routers and another level of "access routers" that run MPLS.

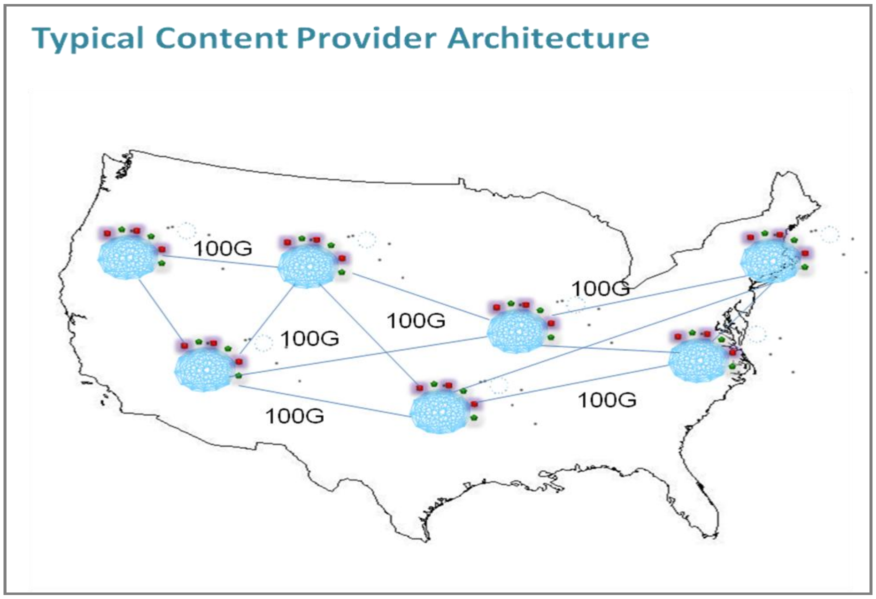

Figure 2.Content Providers' Architecture

There are clear opportunities to connect the MPLS network within the data center to the network that interconnects all the data centers. Content providers want to remove the distinction (or barrier) between the data center and the network and transmit across one simplified MPLS network. Interconnecting data centers is probably the most expensive segment of network expenditure because of remote locations and long-haul routes, which require sophisticated optical equipment. Transmissions over very long distances at high bit rates have previously been impossible without expensive regeneration.

"*MPLS-TP for the service provider is a separate Layer 2 cloud.*

We want this 'true MPLS LSR' to be compatible with our core routers within one cloud".

Content Provider

How Coherent Detection Changed the IP and Optics World

There has been a major breakthrough and paradigm shift in the transport world: what previously was extremely complex optical engineering has now been radically simplified. As the transport area has moved to higher bit rates, for example, from 2.5G to 10G, it has required new hardware (dispersion compensation). When moving from 10G to 40G the preciseness and difficultly of engineering the link increased dramatically and often resulted in shorter reach and other physical tradeoffs. These migration barriers to higher bit rates have been completely resolved by shifting what was complex analogue optical engineering into the electronic and digital domain.

Now, for the first time, a combination of new modulation schemes and post receiver processing has enabled not only higher bit rates, but even longer reach at higher speeds. Brought to market by Nortel Networks, coherent detection is now in development with several vendors. A coherent receiver can "tune" to any wavelength in the spectrum just as one can tune into a radio station. Second-generation coherent receivers (currently in development) will incorporate filters and other optical components that will modulate power across all wavelengths in the spectrum, previously done manually and with much tweaking. Not only does this vastly increase flexibility in wavelength deployment, but there are also the added benefits of decreased loss and lower costs (because of integrated filters), making long-haul routes easier to deploy at higher bit rates and longer distances.

> *"Previously, we could only transmit 2.5G on some of our fiber, but now we can put 100G on that same fiber and go even further with this technology."*
>
> Glenn Wellbrock, Verizon

Coherent detection eliminates the complications of operating on different fiber types. In addition, adding new nodes to a network has been radically simplified because every link on every path can be calculated and readjusted. It has reduced complex engineering tasks and made the network potentially more agile and responsive than ever before.

If you expand on the vision of coherent detection, it can actually enable more of any-to-any transport topology without excessive engineering. Paths in the network can now be established at the higher layers, which can "guide" the optical layer to respond in a more flexible and agile way. Coherent detection has enabled what was typically a "static" optical network to become flexible, making optical equipment more interesting to pair with routing because the dynamic control plane within the routing domain can set up paths that mirror the services that are being transported over the network. *With this intelligence and dynamic control it makes more sense now to integrate transport functionality with routing products (and vice versa) as wavelengths can be established in a less disruptive fashion.*

We expect to see more router platforms with integrated long-haul optics come to market just as we have seen transport products integrating packet technology over the last few years. While IP over WDM has been in existence for awhile, coherent detection now enables the dynamic control plane of the router to set up an any-to-any topology at the transport layer without complex engineering or predefined hardware. This is truly a major shift for the conventional transport world.

Looking Ahead

Although disruptive innovation often threatens to displace current product, the next-generation LSR is not a disruptive innovation; it is sustainable innovation, which is defined as a product that has been improved, enhanced or expanded to meet the current market demand but does not threaten the market directly. In fact, it complements the portfolio.

The next-generation LSR and the packet optical variant are more of a crossover into the transport market than a cannibalization of the core router market. Because content and service providers have already deployed MPLS networks, extending the next-generation LSR platform to include transport features is technically easier to do than having transport-centric vendors become proficient in MPLS. Consequently, router vendors are shifting their attention and exploring the option of adding transport-centric features such as OTN and DWDM.

ACG Research predicts strategic financial benefits for content and service providers with the next-generation LSR because it simplifies core requirements and reduces complexity. If designed well, this lean core switch could be offered with added network processing capability, thus offering the market a scalable Layer 2+ switch that might eventually resemble a core router but at a much different price point. We expect gradations of this development, for example, feature sets that climb the OSI stack to incorporate additional VPN, BGP and multicast features and functionality.

> *"Core routers will still be used in every central office; the next-generation LSR with integrated optics is more likely to replace transport than routing products."*
>
> Service Provider, EMEA

Providers whose requirements for the next-generation LSR include integrated optics want to see the product delivered at transport switching prices, which are approximately 35–40 percent of core router costs. Router vendors do not have to enter this lower margin market but transport vendors do. Optical/transport vendors must move into this space or else face managing their business downward. Transport vendors do not have to become core router vendors, but they do have to deliver on packet interfaces with MPLS (or MPLS-TP) functionality that meet the market requirements in scale as well as protocol feature sets.

Inherently content and service providers believe that router vendors will handle the MPLS portion of an integrated IP and optical product better than transport vendors will. Router vendors will still need to prove themselves on the transport side, but engineering issues that were far more difficult in the past have become easier to solve, and both content and service providers are motivated to solve this issue on the operational side. Accordingly, ACG Research expects content and service providers to roll out next-generation LSRs with or without integrated optics as soon as they become available.

CONCLUSION

Architectural changes and network planning activities are more frequently business driven and customer-centric and next-generation infrastructure must serve a business purpose to provide direct benefits for customers.

The next-generation LSR will deliver a significant business advantage in cost and operational ease of deployment. It will interconnect data centers and make operational activities easier, increase the speed of capacity upgrades, and break the bottleneck inherent in Internet content infrastructure.

Author Eve Griliches, managing partner, ACG Research, offers a comprehensive packet optical transport program consisting of market share, forecasts, white papers, and projects. Contact Eve at egriliches@acgresearch.net.

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