Communications Network Infrastructure

by Mark Bieberich
September 2005

Secure Router Virtualization: Critical Solutions for Optimizing IP/MPLS Network Convergence

Executive Summary

Service providers face innumerable challenges making the transition from planning to implementing IP/MPLS network consolidation strategies. In interviews with senior-level network planners, the following three challenges are among the most important that carriers must solve to execute consolidation plans effectively:

- **Simplifying the IP/MPLS point of presence (PoP):** To keep pace with rapid rates of IP traffic growth, network planners deploy edge, aggregation and core routers in complex hierarchies. The result is an inordinate number of single-purpose routing platforms that exhaust valuable ports for purposes unrelated to revenue generation.
- **Consolidating the number of IP overlay networks:** Many service providers show significant progress toward migrating legacy voice and private WAN traffic to IP networks, but most large carriers still maintain multiple IP overlays for specific services or network functions. Therefore, the opportunity to reduce capital and operational costs through network consolidation remains untapped.
- **Deploying services rapidly and with minimal risk:** One of the most important objectives of IP/MPLS consolidation plans is to improve time-to-market and accelerate revenue generation of new services. This objective proves difficult to meet for most carriers, as complex PoP architecture and remaining operational inefficiencies hamper cost-effective testing and provisioning of new services.

Several critical problems arise from these challenges. With respect to present-day PoP architecture, capital costs accelerate quickly as more systems and fiber are deployed and spared. Network operations and management are strained by the large number of network elements that must be monitored and maintained. This architecture places an unnecessary burden on provisioning new services, managing QoS and ensuring high availability.

To solve these problems, technology vendors must deliver next-generation IP/MPLS core routers aimed at simplifying PoP architecture and consolidating the number of overlay networks to one common IP/MPLS core. As scalability reaches unparalleled levels, vendors must also fulfill an expanding list of stringent product requirements for helping carriers execute on long-term IP/MPLS network convergence plans (see Exhibit 1).

Secure router virtualization (SRV) is a technological solution that will play an instrumental role in helping carriers achieve IP/MPLS network convergence goals. This report examines the fundamental requirements of an effective SRV solution, highlighting its impact on network operations, service provisioning, security and total cost of ownership.

Exhibit 1
Typical IP/MPLS PoP Architecture
Source: Yankee Group, 2005

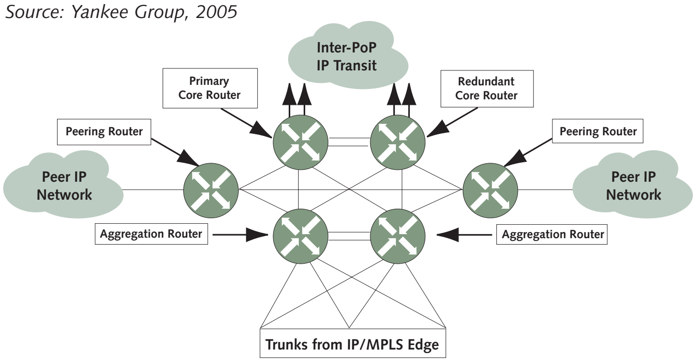


Table of Contents

I. Introduction 2

Secure Router Virtualization Defined 2

Virtualization Technologies Emerge in Diverse Network and IT Environments 3

II. Network Convergence Plans Drive Demand for Secure Router Virtualization. 3

III. Simplification of PoP Architecture Emerges as a Key Driver for Secure Router Virtualization 4

IV. SRV Serves as a Catalyst for Achieving True Network Consolidation. 5

V. SRV Provides an Important Solution for Reducing TCO and Ensuring Secure Service Deployment 5

SRV Provides Carriers with a Secure, Efficient Environment for New Service Introductions. 5

VI. Solution Requirements: Elements of Effective Secure Router Virtualization 6

VII. Conclusions 7

I. Introduction

Service provider network consolidation plans are progressing steadily in every region of the world. Recent research shows that many carriers are nearing completion of initial phases of long-term, comprehensive plans to build next-generation IP/MPLS networks. Network planners understand clearly that the path to cost reduction, service portfolio expansion and superior profitability lies in collapsing overlay networks on a common IP/MPLS core.

Carrier network consolidation plans begin with engineering a core network designed to accommodate unprecedented IP traffic growth. However, carriers must design the next-generation IP/MPLS core with far more than total system capacity in mind. Among other important objectives, carriers must ensure high availability, guarantee quality of service (QoS), protect against threats to security, enable multicast scalability and distribute router resources flexibly to a diverse range of services and applications.

Secure router virtualization—the dynamic, secure distribution of router hardware and software resources to IP services and applications—is paramount to unlocking important benefits to service providers converging disparate networks. This report examines the role of SRV in next-generation IP/MPLS networks, focusing on demand drivers of SRV, its importance to capital and operational cost reduction, and the key technical requirements of SRV solutions.

Secure Router Virtualization Defined

Secure router virtualization is the secure partitioning and isolation of hardware and software resources within a single router, whether the system is single-chassis or multishelf. SRV affords network operators more control over the distribution and partitioning of forwarding and control plane resources for specific services and applications. With SRV, a carrier can isolate and manage distinct infrastructure and routing instances for specific services, such as PSTN voice, Layer 3 MPLS VPNs, video-on-demand (VoD) and dedicated internet access (DIA). Service providers can also use SRV to assign resources to applications such as IP network consolidation, intra-PoP peering, IP transit and BGP route reflection.

From an operational perspective, SRV enables network and PoP consolidation through the definition of fault and administrative boundaries within the router. Service providers can use SRV to maintain administrative boundaries of the original network design, assigning operational tasks over time to the most appropriate staff to improve operational efficiency, enhance security and minimize configuration error. Within this context, SRV affords carriers a mechanism for isolating service faults in protected memory space, reducing the likelihood of a protocol failure or a security attack propagating through the system. This is an increasingly important capability, especially as a larger number of services and applications must be supported by the converged IP/MPLS core.

Virtualization Technologies Emerge in Diverse Network and IT Environments

The use of virtualization technologies in the IP/MPLS core is equally important to a wide variety of networking and IT domains. In fact, as SRV infuses the IP/MPLS core with unprecedented flexibility and control over routing resources, virtualization of storage capacity, server processing power and other utility computing resources have already taken hold in the data center.

The benefits of virtualization apply equally to carrier networks and enterprise data centers, both of which are undergoing complex consolidation efforts. The most salient benefits include simplification of architecture, consolidation of devices, reduction of operational complexity, and improvement in scale driven by efficient and dynamic partitioning of resources. These advantages play a central role in reducing TCO in both networking and IT environments.

Although the use of virtualization in carrier networks and enterprise data centers is still in its early days, early successes and increasing investment show a trend toward widespread adoption. In the next 12 to 24 months, Yankee Group expects advancement in virtualization technologies for networking and IT to closely mirror each other, assuming a prominent role in next-generation architectures.

II. Network Convergence Plans Drive Demand for Secure Router Virtualization

Although a converged IP/MPLS core is simple in concept, it's exceedingly complex to implement, operate and manage. Long-term capital and operational cost savings from convergence are apparent, but near-term expenditures to initiate and manage projects can be daunting. Consequently, service providers demand that core routers, which are among the initial targets of capital outlays in a network consolidation plan, meet critical requirements for establishing the foundation of the converged IP/MPLS core.

Service providers expect new core router deployments to help reduce the cost and complexity of large-scale convergence projects. In response to this fundamental requirement, core router vendors must deliver on the vision of SRV—optimizing router resources to meet critical thresholds of performance, security, cost and service-level agreements (SLAs) associated with IP services and applications. SRV helps service providers realize the most critical goals underpinning network convergence plans:

- **Streamlining operational boundaries:** Application-specific routers still pervade carrier networks, defining operational boundaries on a per-network element basis. This condition leads to a cumbersome and expensive operational model, often requiring dedicated staff and NOC resources for each element. By leveraging a single system, a proven SRV implementation enables carriers to isolate operational domains logically, affording carriers more control over router administration. Moreover, an effective SRV solution allows service providers to streamline router administration at their own pace, keeping current administration and organization structures intact for as long as the carrier requires.

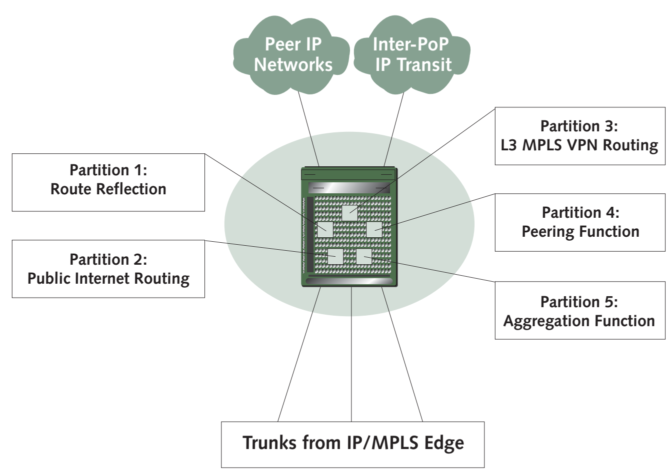
- **Enhancing security:** Routers engineered without the requisite modularity in software architecture to support SRV allow denial of service (DoS) and other attacks to spread to many routing processes within the system. As core routers support an increasing number of services and applications with greater scale, the relative severity of each security attack increases. SRV enhances the security of the converged IP/MPLS core network by maintaining each routing instance and its processes in protected memory space, or physically separate partitions. Therefore, network anomalies in one instance or process do not affect any other maintained by the system.
- **Optimizing scale:** Scale is always important to IP/MPLS core routers, but few systems in operation today have the flexibility to shift forwarding and control plane resources where they are needed most. For example, an effective SRV implementation provides carriers with the ability to ensure that the most bandwidth-intensive services receive the forwarding and control plane resources needed to guarantee SLAs. In this respect, SRV is similar to data center virtualization, where IT applications are allocated compute and storage resources dynamically. In a converged IP/MPLS core, this capability is especially important as real-time traffic and an increasing number of services contend for finite router resources.
- **Ensuring high availability:** In interviews, service providers continue to rank high availability among the most important selection criteria of core routers designed for next-generation networks. Working in conjunction with many other hardware and software reliability features, SRV helps ensure high availability by isolating faults, executing routing protocol restarts and updating software releases—all in protected memory space. As a result, SRV extends high availability to all defined routing instances, not just a single instance configured for all system traffic.

III. Simplification of PoP Architecture Emerges as a Key Driver for Secure Router Virtualization

Because SRV can afford service providers flexible, secure allocation of routing resources, one physical core router can now support a variety of network functions in one system. As a result, carriers no longer need distinct network elements for aggregation, peering, route reflection and other applications (see Exhibit 2). A single system with SRV can decrease the number of nodes and fiber interconnects between routers, reducing the cost and complexity of existing PoP architectures.

It is important to note that SRV can help simplify PoP architecture even when a carrier decides to either prolong or cease network convergence plans. In a single system, SRV provides service providers with the ability to isolate faults and separate administrative boundaries for either multiple IP networks or a single consolidated network. Therefore, service providers can leverage SRV to take advantage of the capital and operational cost savings associated with simplifying PoP architecture. At the same time, SRV provides carriers with an important catalyst for convergence if and when they decide to pursue it.

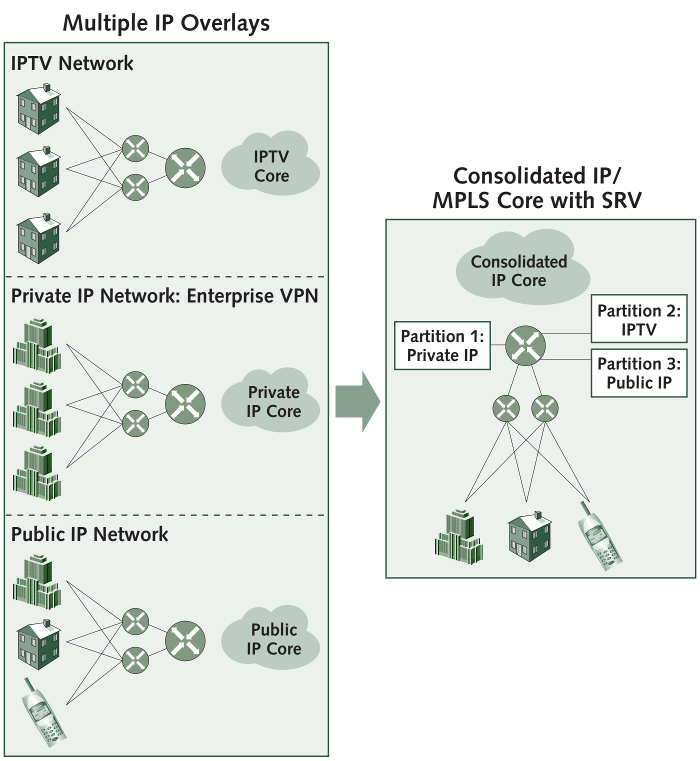
Exhibit 2
Next-Generation IP/MPLS PoP Architecture Using Secure Router Virtualization
Source: Yankee Group, 2005



IV. SRV Serves as a Catalyst for Achieving True Network Consolidation

Yankee Group research shows that carriers are making progress toward converging FR, ATM and TDM overlay networks on IP/MPLS. However, carriers must also consolidate the number of disparate IP networks to realize the full economic and operational advantages of their convergence plans (see Exhibit 3). Many carriers operate separate IP networks for public and private services. Others manage application-specific IP networks, such as for voice and video. By delineating fault and administrative domains for partitioned routing functions and services on a single system, SRV makes true network consolidation a realistic goal to achieve.

Exhibit 3
The Role of Secure Router Virtualization in Consolidating Multiple IP Networks
Source: Yankee Group, 2005



V. SRV Provides an Important Solution for Reducing TCO and Ensuring Secure Service Deployment

Taken together, the four points described in Section II translate to significant capital and operational cost reduction. In fact, TCO is a function of the modularity of the software architecture that makes SRV possible. As modularity increases, so does the potential to take advantage of SRV and reduce TCO.

Near-term contributions to TCO reduction will derive from capital expenditure savings from consolidation of network elements, fiber interconnects and collocation space. However, the greatest potential for TCO savings lies in the inevitable improvement in operational efficiency that SRV makes possible.

During the next 5 to 10 years, Yankee Group expects service providers to use SRV in a steadily increasing percentage of IP/MPLS PoPs, reducing TCO as incremental services and applications are virtualized. Although network consolidation plans will drive SRV deployments in the core first, the need to reduce the number of single-purpose edge platforms will lead to even further adoption of SRV.

SRV Provides Carriers with a Secure, Efficient Environment for New Service Introduction

SRV plays an important role in improving operational efficiency by reducing time-to-market of new services. A product of a modular, distributed, next-generation operating system, SRV enables service providers to use a separate partition for testing and activating new services without having to deploy a new system. Within this partition, SRV allows service providers to install and update the appropriate operating system version for the services under trial without affecting software versions used for existing services. As a result, carriers can begin generating revenue more rapidly, minimizing the total cost of introducing new services.

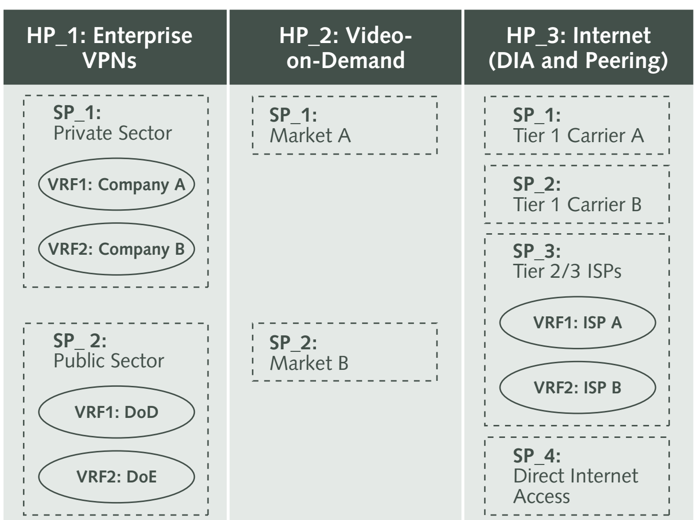
VI. Solution Requirements: Elements of Effective Secure Router Virtualization

The effectiveness of any SRV implementation begins and ends with the architecture of the router and its OS. Some vendor SRV capabilities are limited or non-existent because of a lack of protected memory space or limited separation of processes in the forwarding, control and management planes. However, recent technological developments in the router vendor community indicate that the essential qualities of an effective SRV implementation are available today (see Exhibit 4).

Exhibit 4

Architectural Reference Model for Effective Secure Router Virtualization in a Single Multichassis Core Router

Source: Yankee Group, 2005



Key Attributes:

Scalable across HP, SP and VRF boundaries
Network anomalies in one routing instance do not affect other routing instances
Each partition maintains its own management plane (CLI, SNMP, etc.)
Each partition maintains its own routing processes and applications
Resources can be dynamically reassigned across routing partitions
Ability to share or dedicate hardware resources for each SP

Note: HP = hardware partition, SP = software partition, VRF = virtual routing and forwarding table

The following four attributes summarize the critical requirements of an effective SRV implementation:

- **Flexible separation of hardware resources:** An effective SRV solution affords service providers the ability to determine hardware partitions, or physically separate routing instances, within one system. Hardware partitions ensure fault isolation and provide carriers the flexibility to specify interfaces, line cards, control processors and memory space dedicated to a service domain. Carriers manage each hardware partition as a distinct, secure operational domain within the system, matching appropriate software releases for each partition. SRV isolates faults within each hardware partition, helping protect the rest of the system from protocol failures, security attacks and other anomalies. Moreover, as networks converge and grow, carriers must be able to expand or reassign hardware partition parameters to meet scalability requirements.
- **Flexible partitioning and distribution of software processes:** Within the construct of a hardware partition, SRV allows for configuration of isolated software routing instances, or software partitions.. Each software partition is a fully instantiated and secure software router that maintains its own management interfaces (such as SNMP and CLI), configuration files, log files, alarms and security processes. Carriers can either share or dedicate a single hardware partition's resources for multiple software partitions. By isolating data, control and management plane instantiations, carriers can use software partitions to allocate specific routing resources for particular services, customers and applications. For example, within a hardware partition dedicated to private WAN service traffic, a carrier can determine software partitions for multicast and unicast traffic, applying specific access control lists and QoS parameters according to customer needs. This level of flexibility is only possible with a highly modular, distributed, next-generation software architecture.

- **Scalability within separate operational boundaries:** Although a modular, secure software architecture is the basis of effective SRV, a router must also scale across distributed hardware and software partitions for the system to achieve carrier goals of TCO reduction. It is critical to ensure scalability of both forwarding and control planes by distributing software processes to hardware and software partitions dynamically. In fact, as SRV gains further adoption in the marketplace, total system scalability metrics, such as total throughput and number of routes supported, will become less important than the degree to which partitioned resources can scale independently.

VII. Conclusions

Although the need to collapse disparate networks on an IP/MPLS core is clear, network engineers readily articulate the myriad of challenges that accompany long-term convergence plans. Primary research with the largest IP backbone operators shows an increasing need for a simple, scalable IP/MPLS PoP architecture and an efficient, secure network operations environment. To satisfy both of these broad objectives and therefore reduce TCO, carriers require targeted technology solutions.

SRV is among the most important solutions carriers will adopt to execute network convergence plans. The flexible allocation of hardware and software resources means service providers can optimize performance, scale, security and management of specific services and applications—all within the confines of a single, next-generation IP/MPLS core router. In the past year, Yankee Group has identified a wide range of carriers adopting SRV, including cable companies, incumbent PTTs and broadband ISPs.

For deployment of SRV to meet carrier objectives, the router vendor must deliver a highly modular hardware and software architecture. The system must be distributed and be able to allocate resources to hardware and software partitions in a scalable and secure fashion. Hardware and software partitions must be enabled with true separation of forwarding, control and management plane instances, affording carriers the ability to maximize operational efficiency, minimize the impact of faults, and optimize performance of all services and applications in the converged IP/MPLS core.

Yankee Group

Yankee Group has research and sales staff located in North America, Europe, the Middle East, Africa, Latin America and Asia-Pacific. For more information, please contact one of the sales offices listed below.

Corporate Headquarters

31 St. James Avenue
BOSTON, MASSACHUSETTS 02116-4114
T 617.956.5000
F 617.956.5005
info@yankeegroup.com

EMEA

55 Russell Square
LONDON WC1B 4HP
UNITED KINGDOM
T 44.20.7307.1050
F 44.20.7323.3747
euroinfo@yankeegroup.com

North America

260 Terence Matthews Crescent, Suite 200
KANATA, ONTARIO, CANADA K2M 2C7
T 613.591.0087
F 613.591.0035
canadainfo@yankeegroup.com

Decision Services

Yankee Group Decision Service annual memberships offer clients access to research and one-to-one expert guidance.

Decision Services represent our best value for clients. The services help our members understand industry, regulatory, competitive and market-demand influences, as well as opportunities and risks to their current strategies.

Membership includes an invaluable in-person strategy session with Yankee Group analysts, direct access to a team of analysts, DecisionNotes[sm] and regular Online Decision Forums on relevant topics.

We offer Decision Services on almost 30 selected topics in Telecommunications; Wireless/Mobile Communications; Consumers, Media & Entertainment; and Information Technology Hardware, Software & Services.

Decision Instruments

Yankee Group offers a full portfolio of technology and market forecasts, trackers, surveys, and total cost of ownership (TCO), return on investment (ROI), selection and migration tools. Decision Instruments provide our clients the data required to compare, evaluate or justify strategic and tactical decisions—a hands-on perspective of yesterday, today and tomorrow—shaped and delivered through original research, in-depth market knowledge and the unparalleled insight of a Yankee Group analyst.

Trackers
Trackers enable accurate, up-to-date tactical comparison and strategic analysis of industry-specific metrics. This detailed and highly segmented tool provides discrete proprietary and performance data, as well as blended metrics interpreted and normalized by Yankee Group analysts.

Surveys
Surveys take the pulse of current attitudes, preferences and practices across the marketplace, including supply, delivery and demand. These powerful tools enable clients to understand their target customers, technology demand and shifting market dynamics.

Forecasts
Forecasts provide a basis for sound business planning. These market indicators are a distillation of continuing Yankee Group research, interpreted by our analysts and delivered from the pragmatic stance our clients have trusted for decades.

Signature Events

Yankee Group's Signature Events provide a real-time opportunity to connect with the technologies, companies and visionaries that are transforming Telecommunications; Wireless/Mobile Communications; Consumers, Media & Entertainment; and Information Technology Hardware, Software & Services.

Our exclusive interactive forums are the ideal setting for Yankee Group analysts and other industry leaders to discuss and define the future of conversable technologies, business models and strategies.

Consulting Services

Yankee Group's integrated model blends quantitative research, qualitative analysis and consulting. This approach maximizes the value of our solution and the return on our clients' consulting investment.

Each consulting project defines and follows research objectives, methodology, desired deliverables and project schedule. Many Yankee Group clients combine Decision Service memberships with a custom-consulting project, enabling them to augment our ongoing research with proprietary studies.

Thousands of clients across the globe have engaged Yankee Group for consulting services to hone their corporate strategies and maximize overall return.