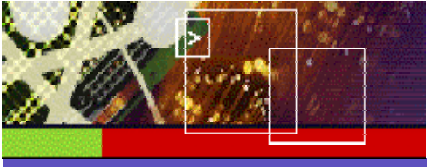

The Multi-Router Approach to a Profitable Network Edge

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Introduction

Carriers have successfully delivered basic services from the network for years, but are facing challenges maintaining or even achieving profitability with their IP deployments. This is in the face of unprecedented scrutiny from their investors and a financial environment that supports very little new capital expenditures. They have identified the network edge as key to driving additional revenue from their infrastructure investments as well as to retain or gain market share.

From a technology perspective, vendors have introduced several router architectures to address the needs of the network edge. These architectures range from the monolithic router, essentially a large core router modified in size for the edge, to the virtual router platform with logical instances of IP routing tables, and finally to the multi-router architecture involving multiple, physical routers within a managed single chassis.

The objective of this white paper is to describe succinctly how a multi-router platform permits the carrier to better derive profitability from the network with minimal new capital equipment while reducing operational expenses. It first outlines the problems service providers face at the edge. Next, it outlines the current categories of router architectures. Finally, the remainder of the document focuses on the benefits of the multi-router category by identifying key business applications where this architecture is advantageous, as well as citing additional improvements the multi-router brings to the functional departments of a service provider.

Overcoming Challenges at the Edge

Although carriers have deployed technology solutions to augment network capabilities at the edge in order to reap the benefits of additional services, they still face the following sometimes conflicting challenges:

Figure 1: Divergent Challenges at the Edge

- **Scalability.** As providers aggregate services and customers, they require sufficient processing power to maintain support of enhanced services while maintaining acceptable SLAs.
- **Service Convergence.** With a goal to minimizing complexity, they wish to converge multiple Layer 2 and Layer 3 services on a fewer number of physical platforms. However, this convergence cannot result in additional operational complexity.
- **Service Isolation.** While converging services, they must ensure availability and reliability. Subscribers have little tolerance for network downtime that translates to costs for the provider in SLA remedy payments, or worse, customer churn. No one service can affect the performance of another.

To address these problems, technology innovators have introduced several different solutions into the marketplace:

- **Monolithic Routers.** Carriers initially redeployed core routers at the edge. Although these devices kept up with the exploding IP bandwidth demand, their architecture did not support the variety of services required at the edge.

- **Rack-and-Stack Method**. To overcome the limitations of single, monolithic routers, carriers racked-and-stacked these devices for scalability. Though this could be considered a precursor/subset of multi-router architecture (discussed below), this model, while still seen today, consumes more rack space, more power, doesn't permit effective sharing of ports amongst multiple control processors, and requires maintaining and managing multiple physical devices rather than a single device. Scalability of this model is limited by individual router limitations – not an optimal solution.

- **Virtual Routers.** The growing need to support layer 2 and layer 3 private networking and other edge services lead vendors to this routing design. Virtual routing creates individual software instances of the forwarding/routing table. This may include line card forwarding processors, but generally shares one or two control processors.

- **Multi-Routers.** The next evolutionary step in routing, the multi-router system addresses a carrier's need to have different levels of control and performance as required by various applications. The multi-router system consists of a collection of routers in a single chassis. What further distinguishes it from earlier designs is the separation of data and control traffic across two separate fabrics. This architecture ensures scalability, with flexibility to increase processing power and minimizing the diminishing returns of the rack and stack method. Additionally, this design introduces multi-tiered management, allowing a group within a carrier to deploy the platform and offer routing/resale services to other units or wholesale customers.

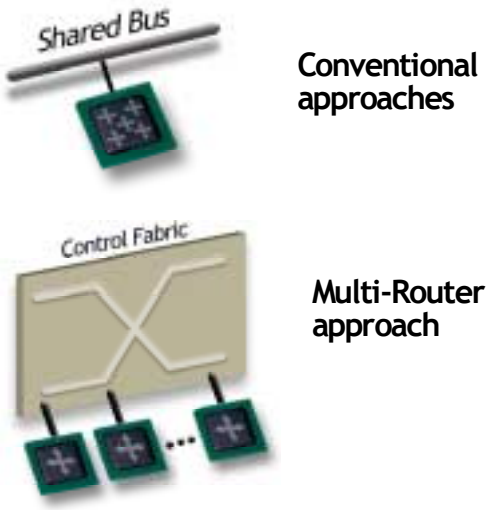


Figure 2: Routing Architecture Evolution

These routing categories, their initial technical challenges addressed, and sample applications are summarized in the following table (Figure 3):

Challenges Addressed and Applications	Rack & Stack	Monolithic Router	Virtual Router	Multi-Router
Logical Partitioning Required			✓	✓
Physical Partitioning Required	✓			✓
IP Enabled Frame Relay	✓	✓	✓	✓
Core IP Network Infrastructure		✓		
Layer 2 and Layer 3 VPNs	✓	✓	✓	✓
Secure VPNs (i.e. IPsec)	✓	✓	✓	✓
Private Routing Services	✓		✓	✓
Service Tiers based on QoS (Priority, Availability, etc.)	✓	✓	✓	✓
Peering/Exchanges and Carrier-Neutral Facilities	✓	✓		✓
Wholesale IP services (bulk)				✓
Wholesale IP services (granular)			✓	✓

Figure 3: An Overview of Router Categories

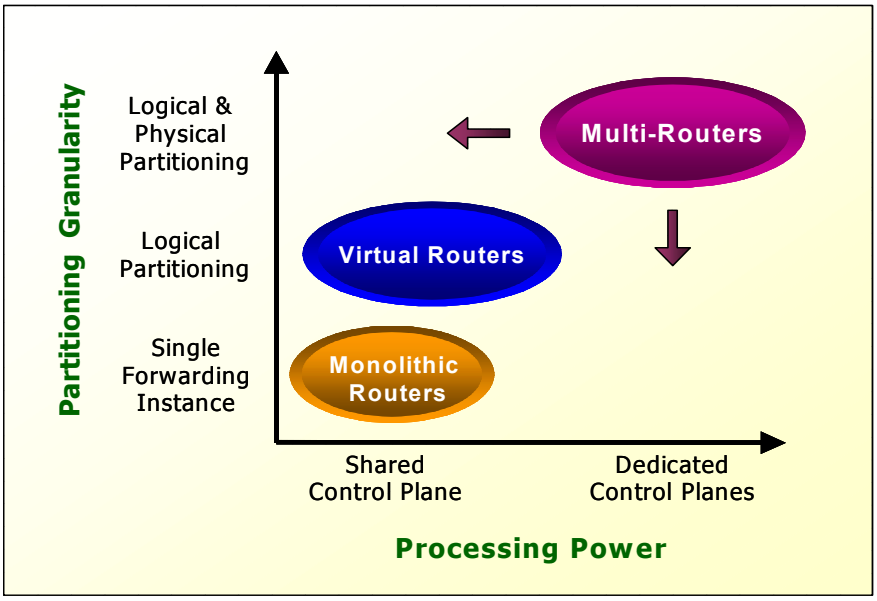
As depicted in Figure 3, each routing category was developed to address new challenges and specific applications. It is important to note that while the multi-router system was created to provide highly partitioned services and ensure processing performance scales effectively – seemingly a direct replacement for the rack and stack method – it also can perform the same basic routing tasks of the monolithic and virtual routers within the same network. This co-existence makes for easier network integration, and does not require a service provider to abandon its existing capital investment.

Zones of Advantage for Multi-Routers

While a multi-router can coexist with earlier architectures, its design has inherent advantages. The positioning chart depicted in Figure 4 defines these advantages along axes of partitioning capability and processing power for applications.

By developing a device with dedicated control planes as well as forwarding planes, the processing power of the multi-router scales according to the level of granularity required. Note that movement along each axis from the point of origin represents technological capability enhancement, but that each successive router category can effectively address most of the same business applications as the earlier categories.

Figure 4: Positioning Router Categories



Due to the granular, physical partitioning capability permitting the dynamic assignment of physical and logical interfaces to different control processors, and implicit gains in processing power, the multi-router architecture is well suited for several applications, described as follows:

- **Wholesale Services.** Wholesalers deploy granular routing services for their customers who may not have routing facilities. These smaller service providers with limited footprint and minimal operational staff generally require their wholesale partner to provide not simply big pipes, which they in turn divide and manage for subscribers, but also require granular services, effectively outsourcing their router infrastructure and operations to the wholesaler. The flexibility of the multi-router architecture promises to meet this requirement.

- **Overlay Networks.** Service providers create overlay networks for communities of interest, application services, content delivery and other applications requiring either premium class of service networking or intelligence not addressed by their standard service offerings. Overlay network models require partitioning for increased reliability and quality of service. Carriers supporting these services today typically deploy multiple logical networks that may leverage common transit routes but often have separate devices overbuilt for the specific service. The multi-router architecture provides the physical overlay aspect, while a common chassis results in lowered management and maintenance costs.

- **Private Routing Services.** Some enterprises desire to leverage IP networking but wish to do so on private backbones, 'with their traffic

separated from the public Internet. Similar to overlay networks, carriers offering private routed IP network services traditionally deploy dedicated routers to support these private backbones through the rack-and -stack method. While this approach technically works and keeps traffic isolated, it is not cost effective and creates management inefficiencies. Multi-routers can handle the scaling of customers and sites requiring this service, as well as the isolation to keep networks private.

- **Peering/Exchanges and Carrier-Neutral Facilities.** Peering points for network interconnection are used to exchange traffic and to provide off-net access/transit between carriers. Whether publicly exchanged at a NAP or through private peering agreements, these interconnections not only tie physical networks together, they require packet forwarding and routing table exchanges. Maintaining state information for the routing tables running BGP, OSPF, IS-IS, RIP and other protocols can tax router memory, and these performance impacts grow exponentially as the size of the attached networks expand. Locations of exchanges for bandwidth brokering/trading or international landing points also face this challenge. As networks grow and peering agreements increase minimum throughput thresholds, routers at peering points will need to scale effectively to keep up. Currently, this means the provider installs an additional router(s) to handle increased performance requirements. Multi-router systems, however, provide a solid, cost effective solution to the scaling and isolation challenges of peering and exchanges.

- **Virtual Private Networks.** Whether based on MPLS or IPsec, IP VPN services are all about restricting data network traffic on a shared infrastructure. Ensuring network privacy at the least means separation of traffic, whether logically or physically. The ability to carve these distinct virtual network routes is achieved through various VPN implementations. MPLS Layer 3 VPNs based on RFC 2547 and BGP/4 segregates traffic, but redistribution of these routes may pose routing table management challenges. Similarly, Layer 2 "Draft Martini" VPNs require substantial processing power when encapsulating protocols such as Ethernet, Frame Relay and ATM in MPLS. And likewise, IPsec encrypted tunneling, and the associated processes of key exchange, consumes significant computing resources. Each of these VPN models can benefit from physical network separation at the router level, as well as the scalability of a multi-router solution.

In addition, the multi-router architecture, by providing physical partitioning, shelters the performance and stability across all carrier services during network attacks or operator-induced instabilities.

Organizational Benefits of a Multi-Router Architecture

Parallel to the multi-router applications listed above are the efficiencies the platform delivers to the carrier's functional units.

Finance

Finance departments seeking to maximize return on investment and demonstrate immediate savings from any new equipment purchases are able to leverage the following aspects of multi-router deployments:

- A pay as you grow CAPEX model limits financial exposure and can reduce time to investment payback.
- Incremental revenues from services based on new per-port and per-router pricing.
- Scalable and differentiated edge router services for higher revenue and margin based on QoS and VPN scalability and multi-tiered pricing architectures.
- A carrier with multiple business units and corresponding services can also leverage the single CAPEX investment.

Engineering

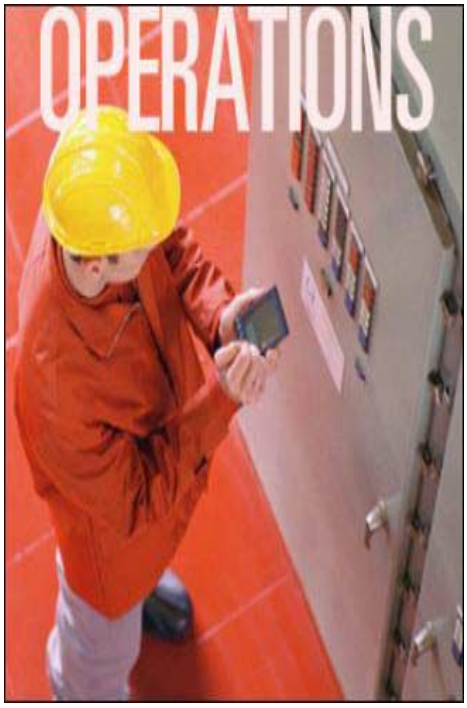
Network Engineering departments are able to leverage the multi-router architecture's technical advantages to gain efficiencies, which in turn reduce CAPEX, OPEX, and lost productivity through the following:

- Scalable control plane and processing power allows flexibility for network engineering designs for initial deployment and network evolution, helping preserve initial capital investment.
- Scalable processing power and high channelization supports more customers/services per device.
- Redundancy of multiple physical routers. This means fewer hot standbys than the rack-and-stack method, and helps the service provider maintain SLA commitments.
- Space and power reductions with single chassis and multiple cards lower infrastructure costs in POP space.

- Service design facilitated by sophisticated QoS support and accounting for customer applications across the platform.
- Data forwarding and control plane scalability based on separate fabrics, with no bus-based control plane contention.
- Only router developed in the last five years specifically addressing the service and scalability needs of the network edge.
- Multi-router architecture to support new managed/unmanaged services.
- Multi-router architecture enables greater VPN scalability and security.

Network Operations

Network Operations groups tend to focus on manageability and operational cost control. As such, they reap the following benefits of the multi-router:



- Management simplicity of a single platform.
- Horizontal distribution of services as opposed to vertical stacking on a single processor results in service simplicity and resiliency, avoiding downtime and configuration errors.
- Dynamic allocation of router resources based on service requirements allows faster network grooming, provisioning, and troubleshooting.
- Network availability increases with highly scalable and reliable multi-router platform.
- Router inventory is minimized by a single system, meaning a single physical install, common sparing, and common operating system.
- Platform enables quicker testing, certification, and deployment of new services based on a common system.
- Simplify topology within PoP between ADM, edge, and core.
- Space and power savings by consolidating on a single platform.

Marketing

New technology translates into to new services, features, and components for product development and product marketing groups.

Specific marketing benefits from multi-routers include:

- Centralized, flexible platform facilitates a faster time to market by deployment of new services based on a common system.
- Multi-router systems enable expedited customer testing and validation.
- Faster development and testing in turn allows the service provider to adapt services quicker to changing market demands. This results in quicker time to revenue and increased customer retention.
- Additional capabilities of a multi-router can be productized or passed on to subscribers as value-added features.
- Improved performance supports higher levels of SLAs.
- Multi-tiered architecture enables new resale/outsourced layer 3 services for enterprises, other providers, and the government. These services can follow outsourcing trends and can lower CAPEX and OPEX for subscribing customers.
- Joint development and marketing of new services between carrier subsidiaries, ventures, and/or partnerships on single platform.
- The multi-tiered management system enables a service provider to offer both managed and unmanaged services and permits service providers to turn over control to their subsidiaries/departments, to subscribing customers or retain control themselves.

Summary and Conclusions

Service providers are increasingly focusing on driving profitability from the network edge, and any new investment must result in cost savings or new revenue opportunities. They require solutions that scale effectively, that permit them to manage complexity, while at the same time guaranteeing reliability and availability. These solutions must also position them for the future by offering the flexibility and processing power to add intelligence into the network for future services. To address these requirements, several IP router architectures have been introduced, including repurposed core routers, racking-and-stacking, and the virtual router.

The multi-router system is the next evolution in IP routing, created to address the challenges of the network edge. The multi-router is designed with dedicated control and forwarding planes in order to improve computational processing as well as to enable granular partitioning of both logical and physical resources. The design promises to solve the divergent challenges of scaling faced by overtaxed processors, service convergence, and isolation. This architecture is an exemplary fit for applications such as wholesale 3services, overlay networks, private routing services, peering/exchanges, IP VPNs and other services requiring highly scalable yet dedicated network processing power.

Enabling these services profitably and efficiently is of high importance to service providers.

Does this mean a service provider needs to replace its current infrastructure with multi-routers? No, the multi-router can coexist within the current environment. While it was designed for and excels in certain applications, it can serve as a complement to the carrier's existing infrastructure. There is room for the multi-router in the network for augmentation whether increasing capacity in an existing POP or in a green-field build.

Multi-router architecture also promises to benefit the functional areas of a carrier through improving CAPEX and OPEX models, facilitating simplified service delivery and support, reducing time to market for new services, improving customer acquisition and retention, and driving productivity to the edge.

Service providers should take a close look at the technology and give serious consideration as to how it could benefit their networks.

About TeleChoice

TeleChoice assists companies in creating new markets around innovative business models, technologies, products, services, and applications. As the strategic catalyst™ for the telecom industry, TeleChoice helps start or greatly accelerate the process of crystallizing a business or market strategy, value proposition, or differentiated position. Playing a strategic role, TeleChoice enables clients to launch new businesses, new markets, and new products and services rapidly and successfully.

Supporting service providers and the technology vendors that serve them, TeleChoice focuses on leading-edge public network technologies. Since being founded in 1985, we have been differentiated by our proven ability to transform new technologies into successful products and services. Our portfolio of offerings helps clients conceptualize, launch, market, and capitalize on innovations in networking—faster, more efficiently, and more profitably.