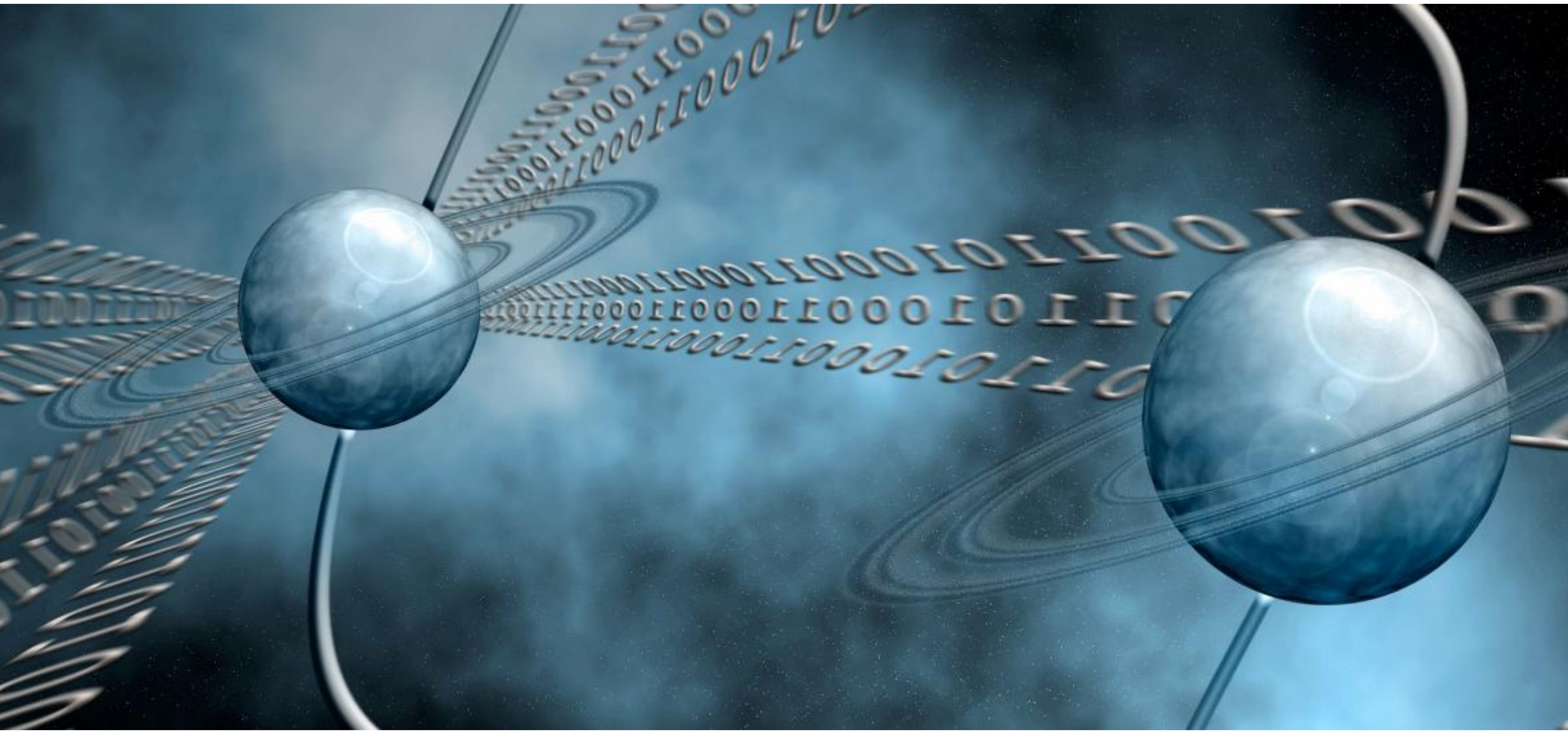
Driving Scale and Operational Efficiency in the IP Core: TCO Analysis of the Alcatel-Lucent 7950 XRS Core Router



Executive Summary

There is significant cost pressure on network infrastructure caused by high traffic growth rates and the failure of service providers' revenues and profits to keep pace. Core network traffic is growing in excess of 50% per year, and new services such as content-rich digital media, cloud and mobile broadband place new requirements on the network for optimal distribution and delivery. Core routers, consequently, must scale rapidly and meet demanding network performance objectives with the lowest possible total cost of ownership (TCO). Operations expense (OpEx) differences, specifically, are the true cost differentiators among competing core router solutions.

The Alcatel-Lucent 7950 XRS core router provides an integrated P-Router and Label Switched Router (LSR) solution with high port and slot density per chassis to deliver increased scale and higher efficiency to meet the requirements of 100G configurations. Other leading core router vendors also provide integrated core router solutions; one vendor offers a hybrid solution that separates the P-Router and LSR functions onto separate chassis.

ACG Research analyzed the TCO of the 7950 XRS core router and other leading core switch/router solutions when deployed on a simulated large core network subject to high traffic growth rates. It found that the OpEx of the 7950 XRS is 43% to 56% lower than the competitions' core router solutions. Capital expense (CapEx) also is lower by 22% to 26%. The system geometry and superior port and line-card slot density of the 7950 XRS contribute to its TCO advantage, especially for key controllable operational expenses such as space and power.

Key Takeaways

The Alcatel-Lucent 7950 XRS core router provides an integrated P-Router and Label Switched Router solution for scaling IP core networks. Its TCO is compared to two other leading integrated router solutions as well as a hybrid solution that implements the P-Router and LSR functions in separate chassis.

The 7950 XRS demonstrates:

- 43%–46% lower operations expense (OpEx) compared to integrated core routers and 56% lower OpEx than the hybrid solution.
- Significant efficiency gains driven by programmable 400G silicon that results in higher port densities without sacrificing functionality, requiring fewer chassis and network elements, and consuming less power and space than competing core router solutions.

Introduction

New services such as content-rich digital media, cloud services and mobile broadband are driving IP/MPLS core network traffic demand at annual growth rates in excess of 50%. However, service providers' revenues and profits are not keeping pace with traffic growth. At the same time new services such as cloud, video collaboration, and mobile broadband require higher network availability and are less tolerant of packet delay and jitter. This puts tremendous cost pressure on network infrastructure. Core routers, consequently, must flexibly support rapid scale increases and meet demanding network availability objectives with the lowest possible total cost of ownership.

Some of the specific issues service providers must address in their core networks:

- How should scale and low cost be provided to meet rapid traffic growth?
- What is the optimal mix of transport, switching and routing infrastructure in the core network?
- How can flexibility to changing demand conditions be provided?
- How can service providers minimize operations expenses (floor space, power, product qualification, etc.)?

These issues are examined through a TCO analysis that compares the Alcatel-Lucent 7950 XRS that integrates IP and LSR into a single chassis with two other integrated router solutions and a hybrid IP routing and LSR solution where the IP router and LSR functions are implemented on separate chassis. The analysis focuses on operations expense. Specifically, OpEx elements, which include floor space, power, cooling, training, and testing and certification operations expenses, are analyzed in detail because they are clearly quantifiable costs that can be minimized and the benefits captured. Capital expense and CapEx derivatives (vendors' service contracts) also are analyzed. However, it is assumed that market forces will drive per-port costs to parity and controllable OpEx will drive the true cost of ownership differentiation between competing core routing solutions.

TCO comparisons are made by modeling the build-out of a large core network subject to high traffic growth rates that are caused primarily by increases in bandwidth utilization by end users during the peak usage period. These increases are related to more 1) content-rich media usage from wireline and mobile broadband, 2) enterprise users and 3) cloud services.

Overview of the TCO Modeling Process

Figure 1 provides an overview of the TCO modeling process.

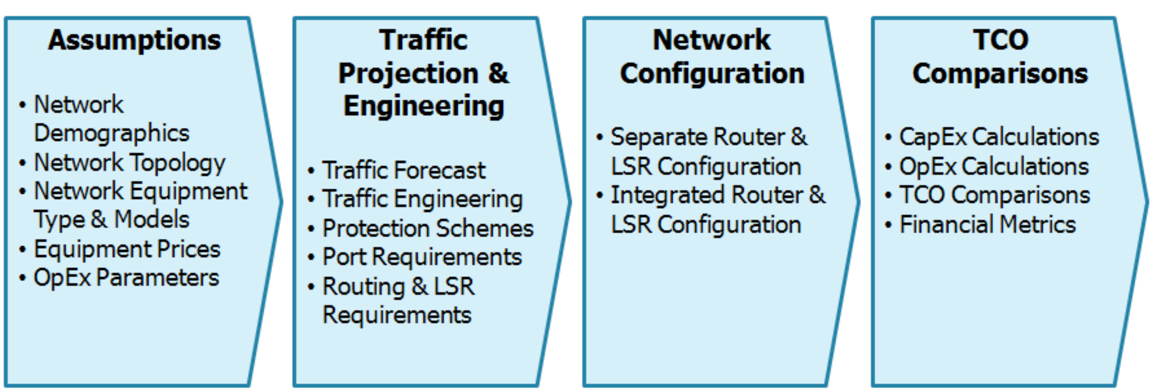


Figure 1 – TCO Modeling Process

The modeling process is a bottom-up analysis that is similar to the one used to design and build an actual network. It begins with a characterization of subscribers' demographics: number of subscribers, their locations, and individual traffic demands. The process also includes the specification of the network topology, the location of each network node and the physical links between the nodes. Vendors' list prices and data sheets are used to specify the performance, configuration, and price of each network element, including each chassis, its common equipment and each line-card. This is identical to the way system vendors prepare bills of materials when submitting bids to service providers. OpEx parameters model OpEx items such as power, floor space, training, and testing expense.

Once the input assumptions and data are established, a traffic projection is made for an n X n traffic matrix where n is the number of nodes in the topology for every study year. These matrices are then used to project traffic and port requirements at each network node by applying an OSPF routing algorithm to each demand matrix subject to the defined network topology.

Once port requirements are known at each node every routing and switching solution is configured according to its design rules. These configurations then are used to calculate CapEx and OpEx using the equipment price lists and the OpEx input parameters.

Network Topology

Figure 2 sketches the network topology used in the study. The topology is representative of a large national core network where each node serves a major metro area. Fifteen PE-router nodes and five core nodes are modeled. Although the traffic forecast and traffic engineering algorithms are applied to the entire network, TCO modeling is done for the five core nodes only.

Demand Forecast

Table 1 shows the number of households passed in each metro area (node). Although the core network demand is assumed to come from sources such as households, enterprise establishments and mobile users, only households are modeled. They are used as a proxy for all demand sources because numbers of enterprise establishments and mobile users are tightly correlated with the number of households. The model assumes a 30% penetration rate of subscribers for passed households.

The demand model assumes that bandwidth on the core network during the busy period per user will increase at a compound annual growth rate of 30%. The growth rate is driven by the expected increase in usage of content-rich media in all market segments. Also, the availability of broadband access and average access speeds keeps increasing because of national infrastructure projects and access technology advancements (for example, DOCSIS 3.0, DSL vectoring, PON, public WiFi, and 4G mobile). This growth rate, however, is lower than most industry projections for the metro area because content caches and video servers are expected to be located within each metro area to reduce the amount of unicast video that is sent across core networks.

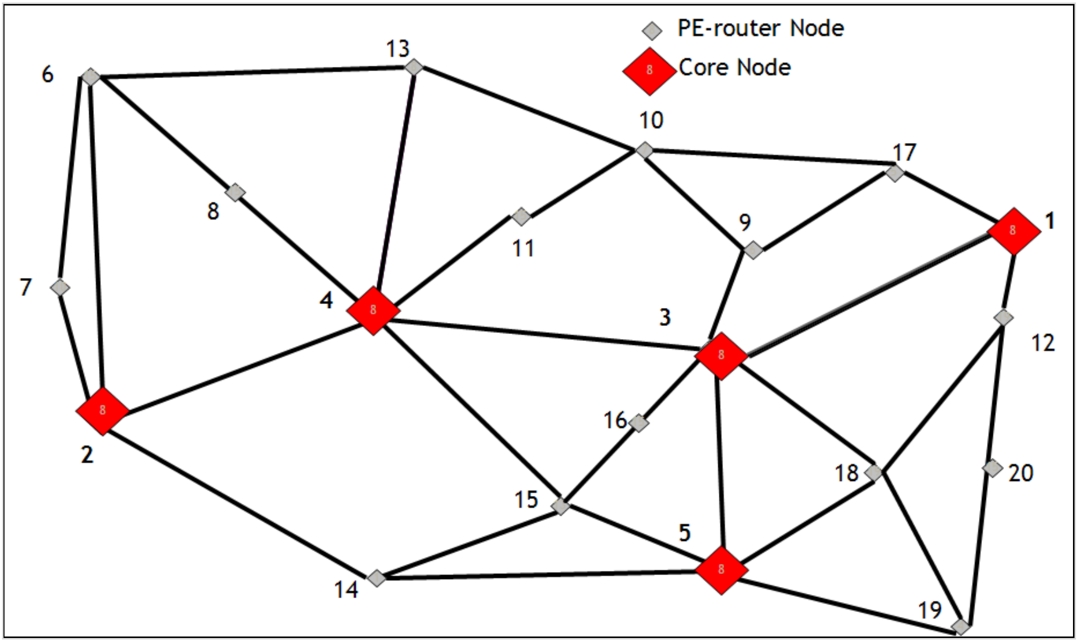


Figure 2 – Model Network Topology

Node Name	Households Passed
Node 1	8,240,000
Node 2	6,670,000
Node 3	3,660,000
Node 4	3,200,000
Node 5	2,820,000
Node 6	2,790,000
Node 7	1,950,000
Node 8	1,570,000
Node 9	2,260,000
Node 10	2,440,000
Node 11	1,350,000
Node 12	1,150,000
Node 13	2,510,000
Node 14	1,080,000
Node 15	1,070,000
Node 16	1,050,000
Node 17	2,100,000
Node 18	920,000
Node 19	910,000
Node 20	900,000
Total	**48,640,000**

Table 1 – Households Passed

Figure 3 shows the projected amount of traffic either originating or terminating in the largest, smallest and median core network nodes. The figure indicates that traffic is concentrated in a few large nodes with a long tail where most nodes are much smaller.

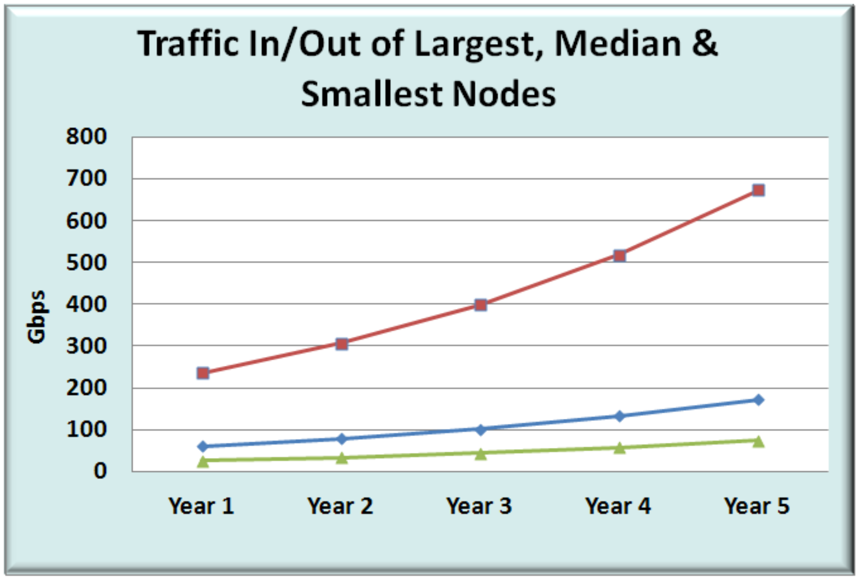


Figure 3 – Traffic Originating/Terminating at Largest, Smallest and Median Core Nodes

Core Routing and Switching Solution Alternatives

The TCO study compares the Alcatel-Lucent 7950 XRS core router to other leading integrated router solutions and to a hybrid design that uses separate P-Routers and LSRs. Each solution is configured to meet identical PE-interconnect port requirements at the interface between the core network and provider edge and internal to the core network. The PE-interconnect ports are 10GE; the core ports are 100GE. The integrated router provides Layer 3 routing of local traffic that is going into or out of the core network and Layer 2/2.5 switching (LSR) for transit traffic in the core network. The separate P-Router and LSR solution provide identical functionality to the integrated router solutions. However, the P-Router and LSR functions are housed in separate chassis. One or more 100GE network links are required to connect the P-Router and LSR chassis.

Figure 4 illustrates the architectural comparisons.

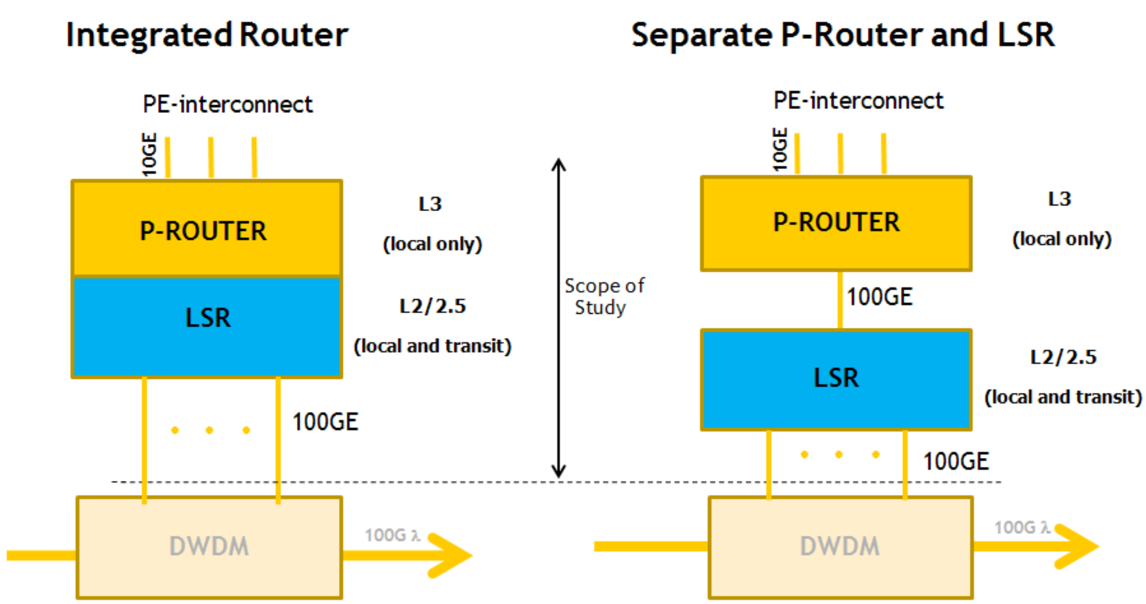


Figure 4 – Integrated Router & Separate P-Router and LSR Network Schematics

All routers and the standalone LSR system include multichassis capabilities. The Alcatel-Lucent 7950 XRS-20 can be upgraded to the 7950 XRS-40 model, which doubles the number of system slots to 40 slots and only requires an additional multichassis system shelf when three or more chassis are combined in a single node. The other integrated router solutions and the standalone LSR require the multichassis system shelf when two or more chassis are combined in one node.

- The Alcatel-Lucent 7950 XRS-20 chassis has 20 line-card slots; the other integrated router chassis and the LSR chassis have 16 line-card slots.
- 7950 XRS line-cards have much higher port density than the integrated router alternatives and the LSR.
- The 7950 XRS 100GE line-card has four ports; other integrated router line-cards support one 100GE port per line-card[1]; and the LSR line-card provides two 100GE ports.

OpEx Comparisons

Figure 5 compares cumulative five-year OpEx[2] for the four core routing solutions.

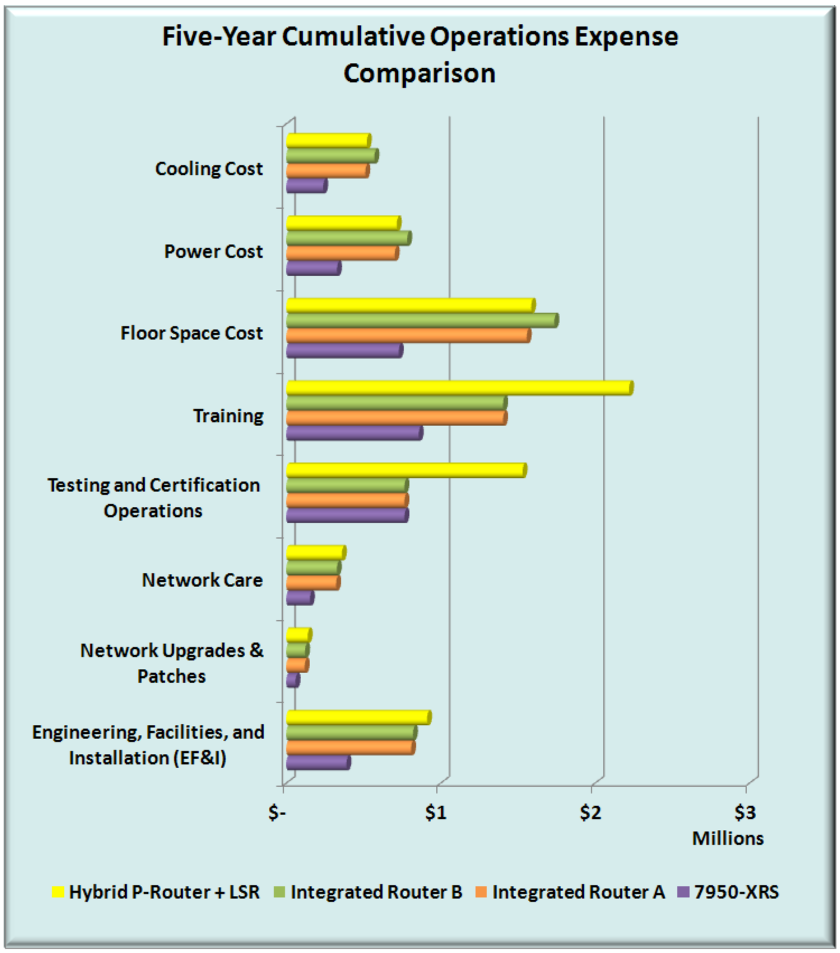


Figure 5 – Five-Year Operations Expense Comparison

[1] The 400 Gbps slot capacity of the 7950 XRS aligns efficiently with 100 GE port requirements. Competing core routers strand slot and system capacity because their slot capacities do not align with 100 GE port requirements. For example, one competitor's 140 Gbps slot capacity strands 29% of the available capacity when used for 100 GE ports.

[2] Vendors' service contract costs are included as part of CapEx rather than OpEx because they are explicitly linked to equipment cost and are included in each vendor's contract negotiation process.

7950 XRS OpEx is approximately one-half that of the other solutions: 43% lower than integrated router A, 46% lower than integrated router B, and 56% lower than the hybrid solution. The OpEx of the 7950 XRS is lower for two primary reasons.

1. Fewer chassis: The higher slot and port densities of the 7950 XRS allow it to meet the port requirements of the network with fewer chassis. Also, the hybrid solution must have several additional chassis because it requires a minimum of two chassis at each node. More chassis under management equate with more work, especially for network care; network upgrades and patches; and engineering, facilities, and installation expense categories. Cooling, power and floor space expenses are all driven by power consumption. Much of the power in a system design is consumed by the common equipment of each chassis. Therefore, all environmental expenses increase as the number of installed chassis increases.

2. Fewer types of network elements: Each system type (P-Router, LSR, multichassis shelves) requires its own training and testing and certification operations program. These costs are identical for the three integrated routers types. However, integrated routers A and B also require multichassis configurations, the 7950 XRS solution does not. Integrated router solutions A and B have somewhat higher training and testing and certification expenses than the 7950 XRS solution. The hybrid solution has four system types (P-Router, P-Router multichassis system, LSR, and LSR multichassis system) and has the highest training and testing and certification expenses.

CapEx Comparisons

The Alcatel-Lucent 7950 XRS solution has lower CapEx over five years as compared to the three alternative solutions. 7950 XRS CapEx is 26% lower than both of the other integrated router solutions and 22% lower than the hybrid P-Router and LSR solution. Most of this cost reduction is due to lower equipment costs and vendors' service contract costs[3], which are explicitly linked to initial equipment costs. The higher port density and greater line-card slot capacity of the 7950 XRS is the source of the cost savings. Higher line-card port density allows the common costs of the line-card to be spread across more ports and thus lowers the per-port cost. Similarly, more line-card slots per chassis allow chassis common costs to be spread across more line-cards and, therefore, reduce per port costs at the system level.

The hybrid P-Router and LSR solution has a slightly better CapEx comparison to the 7950 XRS than the other integrated routers. This is because of an assumption of lower pricing for the core network port connections of the single-purpose LSR platform. Pricing is lower because of the fractional value delivered, as well as assumptions that the implementation of Layer 2/2.5 switching functions costs somewhat less than Layer 3 routing functions. However, the hybrid solution requires back-to-back 100GE ports to connect the LSR to the P-Router. This gives back much of the cost savings achieved by implementing only Layer 2/2.5 switching in the LSR chassis.

[3] Vendors' service contract costs are annual fees charged by the system vendors for software maintenance and upgrade services.

Conclusion

New services such as content-rich digital media, cloud services and mobile broadband are driving core network traffic demand at growth rates in excess of 50%. This puts tremendous cost pressure on network infrastructure. Core routers, consequently, must support rapid scale increases and meet demanding flexibility and availability objectives with the lowest possible space, power, cooling, and maintenance costs in order to minimize TCO.

The TCO of the Alcatel-Lucent 7950 XRS core router was compared to two other leading integrated P-Router and LSR solutions and to a hybrid P-Router and single-purpose LSR solution that separates the P-Router and LSR functions into separate chassis. OpEx comparisons were emphasized because they are readily defensible, quantifiable, and recurring. As such, they are true cost differentiators between competing core routing solutions, assuming market forces drive port costs to parity in the contract negotiation process. The study found OpEx to be 43% lower for the 7950 XRS as compared to integrated router A, 46% lower than for integrated router B and 56% lower than for the hybrid solution.

A key driver of the lower OpEx of the Alcatel-Lucent 7950 XRS is that its design necessitates fewer chassis to meet the same network traffic requirements and uses a single chassis type throughout the network to support both LSR and P-Router requirements. The 7950 XRS is powered by 400G router silicon (the Alcatel-Lucent FP3 chipset launched in June 2011), which delivers market leading port capacity per rack and the ideal geometry to fully utilize the 20 slot capacity of the 7950 XRS-20 for 10, 40 and 100G port configurations. The 7950 XRS requires fewer deployed chassis and has the ability to upgrade to 7950 XRS-40 to double the capacity. This reduces maintenance cost as well as cooling, power and floor space expenses. Fewer chassis consume less power than network configurations with higher numbers of chassis. The use of one integrated router per node by the 7950 XRS reduces training and testing and certification operations costs as compared to more complex network designs. This is especially true when the 7950 XRS integrated router solution is compared to the hybrid solution.

The 7950 XRS solution also has lower CapEx over five years as compared to the three alternative solutions. 7950 XRS CapEx is 26% lower than both of the other integrated router solutions and 22% lower than the hybrid P-Router and LSR solution. CapEx costs for the Alcatel-Lucent 7950 XRS are lower than the other integrated routers and hybrid solutions because of its higher port density and slot capacity per chassis.