

## Executive Summary

The modern data center has undergone a series of changes that have significantly impacted business operations. Applications have evolved from being client-server to services oriented architecture-based (SOA). An application is implemented as a series of connected components distributed over and running on multiple servers with shared workloads. Server virtualization maximizes server utilization and enables resiliency and agility while storage convergence and virtualization yield similar benefits. The size of data processing and storage operations are steadily increasing.

Data center traffic scale and volatility are growing in response to these data center changes. Traffic flow patterns are changing as well. In addition to the traditional flow of traffic from servers to the data center core (N-S), it also flows from server to server and from server to storage (E-W) in the modern data center. Consequently, data center network infrastructures must support ever increasing scale and any-to-any connectivity.

QFabric meets the needs of the modern data center by simplifying network operations, reducing network latency and congestion, seamlessly integrating with existing network infrastructure and services, and delivering scale without adding cost and complexity.

ACG Research conducted a total cost of ownership (TCO) comparison of QFabric<sup>1</sup> versus the market share leader's network architecture for a mid-scale to large-scale 10GbE data center. It found that QFabric achieves 58% to 76% lower TCO and has more linear scaling of capital expense (CapEx) and operating expense (OpEx).

1. This study was conducted comparing shipping products as of October 2011.

## Key Takeaways

Juniper Networks QFabric provides:

- Any-to-any connectivity
- Location-independent low latency and services
- Simplified management
- Orchestration integration

Compared to the market share leader's network architecture, QFabric has:

- 58% to 76% lower TCO
- 58% to 75% lower CapEx with better scaling because of the reduced number of chassis and racks
- 53% to 77% lower OpEx due to simplified management
- 68% to 89% lower power consumption because of fewer chassis and racks

## Introduction

A TCO analysis is used to compare Juniper Networks QFabric versus the market leader's multitier architecture, which exhibits the traffic scale, volatility and any-to-any traffic patterns of a modern data center. Traffic and network infrastructure requirements in the modern data center are characterized by:

### Single Switch with Seamless Integration

Juniper's QFabric is an architecture that can support from a few hundred to up to 6,000 ports via 100+ physical switches, which act as a single logical switch.

How should enterprises get started with QFabric?

Should they be concerned about interoperability issues?

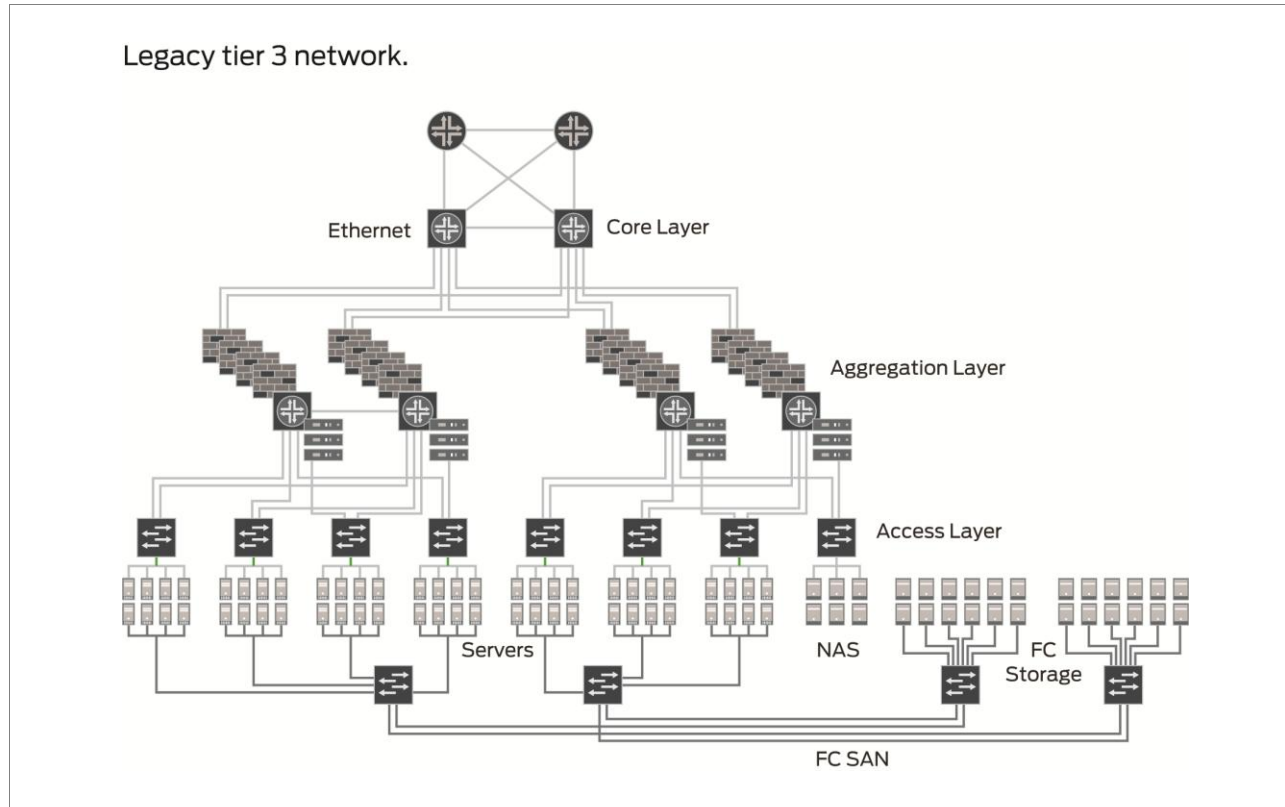
QFabric's single logical switch requires three Juniper-developed components to run (see accompanying description of the QFabric architecture). This design is analogous to the three main components of any standard modular Ethernet switch: line cards, backplane switch fabric and routing engines.

Just as a switch chassis has standards-based interfaces so that it can interoperate with other vendors' equipment, QFabric solutions also have standards-based interfaces so that they also can work with other vendors' devices. Evolving to QFabric can start with a single rack.

- Any-to-any connectivity: Server and storage virtualization and SOA employ connected components that are distributed across and run on multiple servers and storage units. Workloads are shared with allocations frequently changing. There are large numbers of server-to-server and server-to-storage traffic flows that are characterized as E-W flows.
- Resilient and agile: Storage convergence and virtualization enable delivery of on-demand compute capacity expansion and contraction as well as seamless state-aware mobility of data center workload. This increases traffic volatility and requires a resilient and agile network infrastructure.
- Location independent network performance and services: Storage convergence, virtualization, cloud computing and virtual machine mobility technologies such as vMotion require that network performance and services be location independent. Layer 3 routing and services such as VLAN, subnets and VRF must all be location independent.
- Always-on and responsive infrastructure: Cloud computing requires always-on, always-responsive infrastructure with dynamically shared resources to enable efficient, agile and scalable service delivery.
- Scalable: Overall network traffic is growing at up to 85% per year. This is driving an ever increasing scale of the data center (the big data problem). A scalable infrastructure is one in which TCO grows linearly, even though traffic and data processing workloads are growing exponentially.

## Problems with Traditional Multitier Data Center Architectures

Traditional data center architectures employ a multitier structure to accommodate increasing traffic loads. Figure 1 shows such a multitier environment.



**Figure 1 – Traditional Multitier Data Center Architecture**

The multitier architecture has a negative impact on both application performance and the economics of the data center.

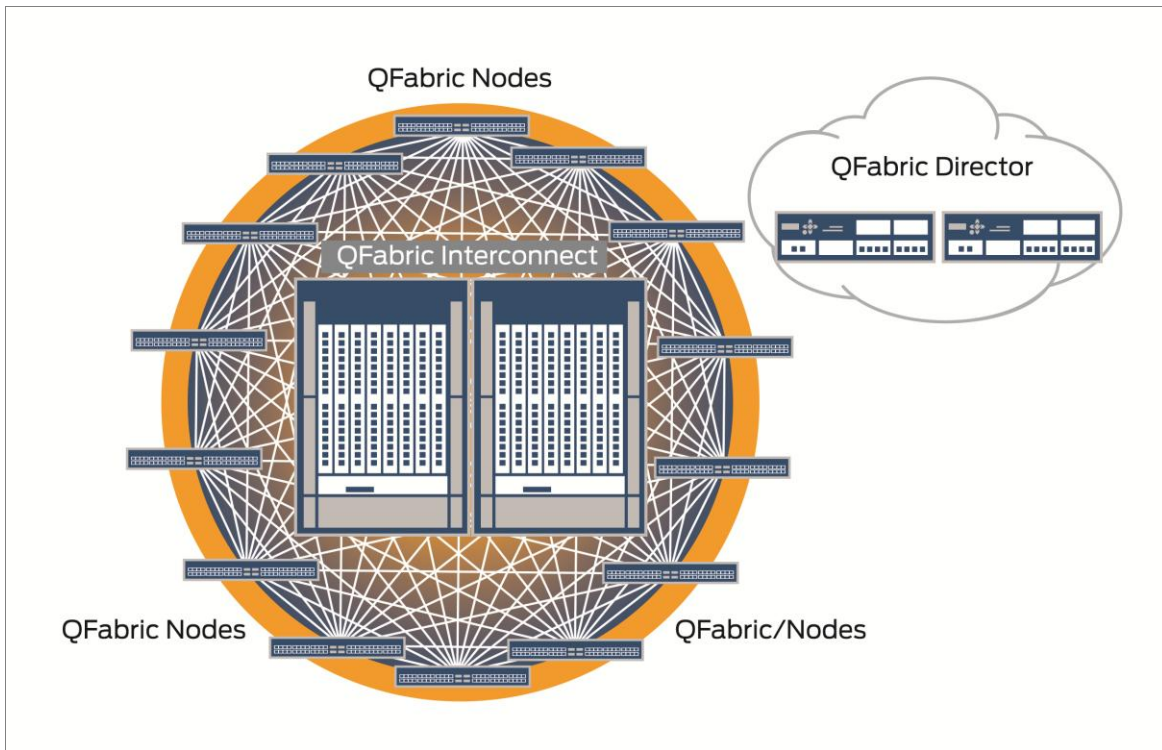
**Performance:** Traditional data center architectures use a hierarchical “tree structure” with switches deployed in multiple layers to accommodate network scale. This forces traffic into a north-south pattern because traffic between two switches at the same layer must travel up to the next layer in the hierarchy and then back down again to reach the adjacent switch. This was not a serious performance issue for legacy monolithic software applications where data processing was wholly contained within a single server, and traffic flows were typically between routers and the switching core. This “location-dependent” network performance, however, imposes serious latency and bandwidth penalties in the modern data center.

**Economics:** The market leader’s multitier data center architecture is also costly from an operational standpoint. As virtual machines migrate between virtual servers, the network paths between them change. This process adds tremendous management overhead as IT struggles to keep track of and maintain connectivity between virtual machines through the tree structure in a highly dynamic environment. Ultimately, managers are forced to make tradeoffs between network performance,

scalability, and management complexity, deciding between user experience and economics to meet their particular data center network requirements.

## What Is QFabric?

In designing QFabric, Juniper has essentially taken the three basic components of a traditional switch fabric (line cards, backplane and routing engines) and broke them out into independent, standalone devices: QFabric Node, QFabric Interconnect and QFabric Director, respectively. Figure 2 depicts the QFabric architecture.



**Figure 2 – QFabric Architecture**

- **QFabric Node:** In the QFabric architecture, the QFabric Node—analogue to the line cards that reside within a chassis switch—is a high-density, fixed-configuration one rack-unit edge device that provides access into and out of the fabric. The QFX3500 hardware not only acts as a QFabric Node edge device in a QFabric architecture, it can also serve as an ultra-low latency, high-performance standalone 10GbE top-of-rack switch in extremely demanding data center environments.
- **QFabric Interconnect:** In QFabric architecture, the switch backplane is represented by the QFabric Interconnect device, which connects all QFabric Node edge devices in a full mesh topology.
- **QFabric Director:** The Routing Engines embedded within a switch are externalized in the QFabric architecture and called the QFabric Director, which provides the control and management services for the fabric.

## Solutions Delivered by QFabric

QFabric is new network architecture (fabric) designed to meet the needs of the modern data center by achieving optimal scale and performance without adding complexity. It features:

- **Simplicity:** By presenting itself as a single switch running the Junos operating system (OS), the QFabric architecture greatly simplifies data center management. By reducing the number of switches required in the data center network, the QFabric architecture significantly lowers complexity and operational expenses as well as power, space and cooling costs. In addition, to maximize network uptime, QFabric is designed as a reliable carrier-class infrastructure with no single point of failure or downtime for reconfiguration and maintenance.
- **Performance:** The QFabric architecture's any-to-any connectivity supports the high-speed server-to-server communication so crucial for modern data center networks. Ultra-low deterministic latency provides an order of magnitude improvement in performance over traditional network architectures, making QFabric effective at supporting latency-sensitive applications, east-west traffic flows, virtualization, cloud computing and other high-performance data center initiatives.
- **Support for virtualization and convergence:** The QFabric technology's flat, nonblocking and lossless architecture is optimized for server virtualization, making it easier for enterprises to eliminate "stranded capital" that results from underutilized server and storage assets. QFabric also supports converged traffic at 10GbE access port speeds. With QFabric, enterprises can run Fibre Channel, L2, L3 and Fibre Channel over Ethernet (FCoE) on the same data center network. QFabric eliminates the trade-offs among simplicity, performance, scalability and cost compared to the market leader's multitier data center network architecture.
- **Green:** The QFabric architecture is environmentally conscious, allowing enterprises to optimize every facet of the data center network while consuming less power, requiring less cooling and producing a fraction of the carbon footprint of legacy multitier data center networks.

## TCO Analysis

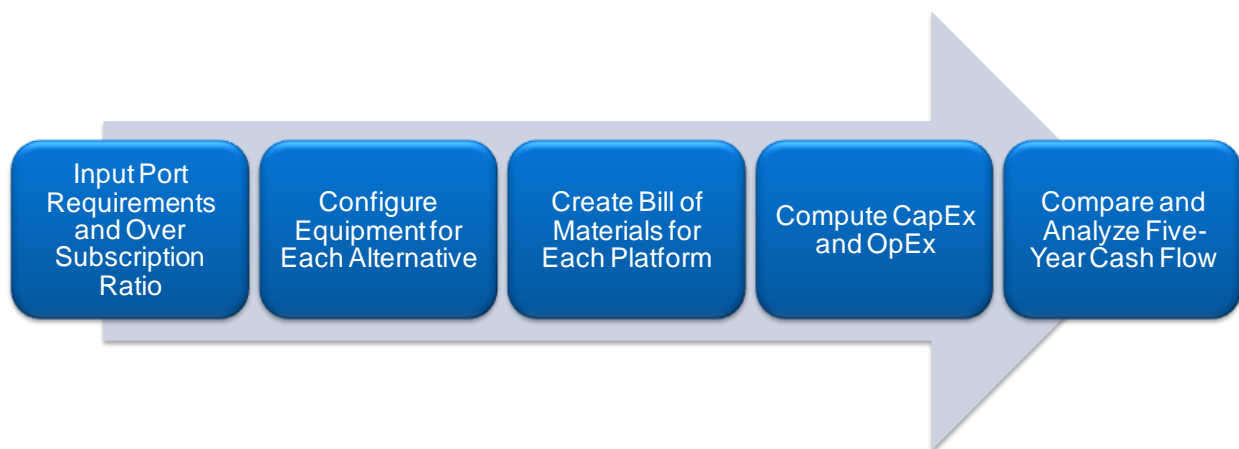


Figure 3 – TCO Analysis Methodology

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## Juniper Fabric Technology Options

Fabric technology provides the ability for multiple interconnected devices, such as switches, to operate as a single, logical device. This dramatically reduces the number of managed devices, links, and layers in the data center, delivering an extremely efficient and high-performance network.

**One-Tier Solutions:** QFabric is designed for large data centers (500 ports or more). It employs 10GbE connectivity and enables the entire data center network to be managed as a single switch based upon the Junos OS.

**Two-Tier Solutions:** For data centers that are primarily 1GbE and/or require less than 1,000 10GbE ports, Juniper EX Series switches connected in a two-tier design using Juniper's Virtual Chassis technology are a good choice.

The EX4200 fixed-configuration switches are good for 1GbE speeds for top-of-rack design; EX4500 fixed-configuration switches support 10GbE speeds for top-of-rack designs.

EX8200 modular switches, which offer very high 1GbE and 10GbE port densities, resiliency and high-performance advantages, are good for data center core/aggregation deployments.

All three EX Series switch platforms support virtual chassis technology, allowing customers to collapse their networks into a single switching layer and manage multiple independent switches as a single logical device.

The analysis methodology begins with input assumptions on the number of server ports and the oversubscription ratio. Large enterprise data centers typically have 750 to 2,000 10GbE server ports and oversubscription ratios of 6:1. Data centers with intense computing needs such as those supporting financial trading floors or modeling for oil and gas exploration have higher port requirements and lower oversubscription ratios (typically 3:1).

Once the inputs are established, each alternative is configured according to its tiered structure, and the number of chassis and the port requirements for each chassis are computed. This is used to create a bill of materials for each platform and each alternative. CapEx and OpEx using list prices are then computed. OpEx is composed of vendor maintenance fees, power and space, and network operations. Network operations expense is further broken down into planning, implementation, and network operations and optimization expenses.

The final step in the analysis consists of comparing and analyzing the five-year cash flows of the two alternatives.

## TCO Comparison

The TCO comparisons between QFabric and the multitier architecture are done for a range of 1,000 to 5,000 server ports and for oversubscription ratios of 3:1 and 6:1. Over these ranges, QFabric offers a 58% to 76% TCO savings compared to the multitier architecture. CapEx is 58% to 75% lower and OpEx is 53% to 77% lower.

Figure 4 shows the TCO comparisons for an oversubscription ratio of 3:1. Figure 5 shows the TCO comparisons with an oversubscription ratio of 6:1. Each column on each chart is total TCO over a five-year study period.

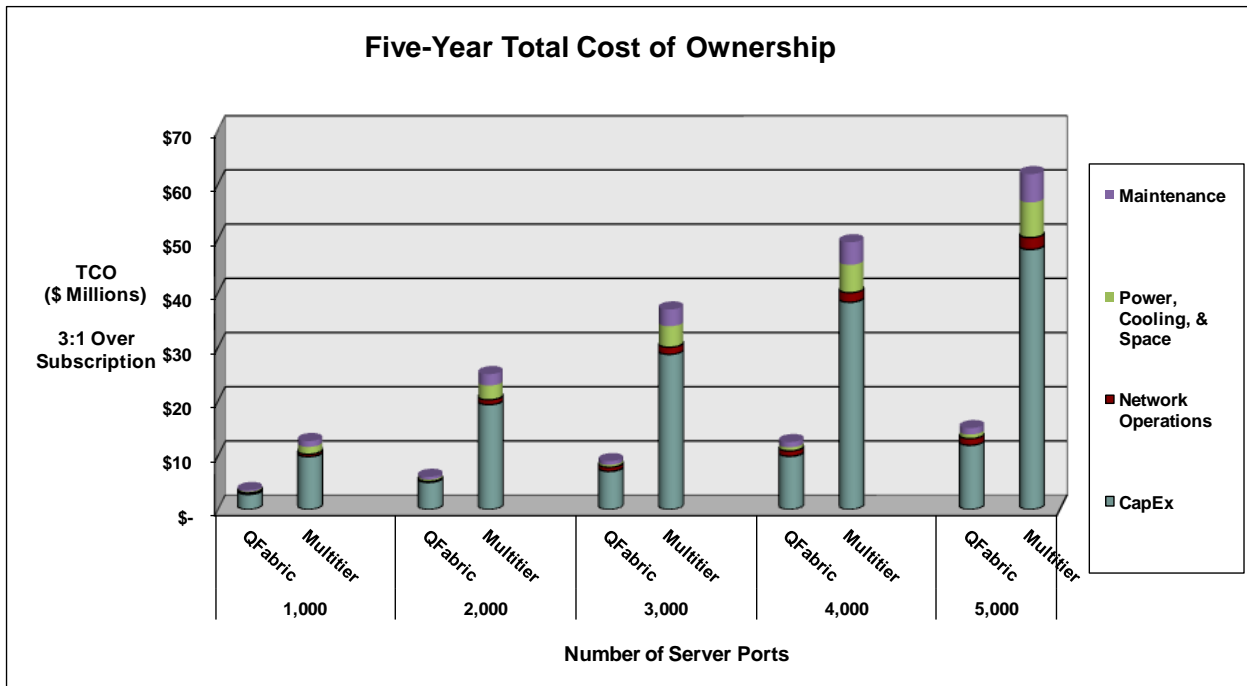


Figure 4 – Five-Year Total Cost of Ownership with 3:1 Oversubscription

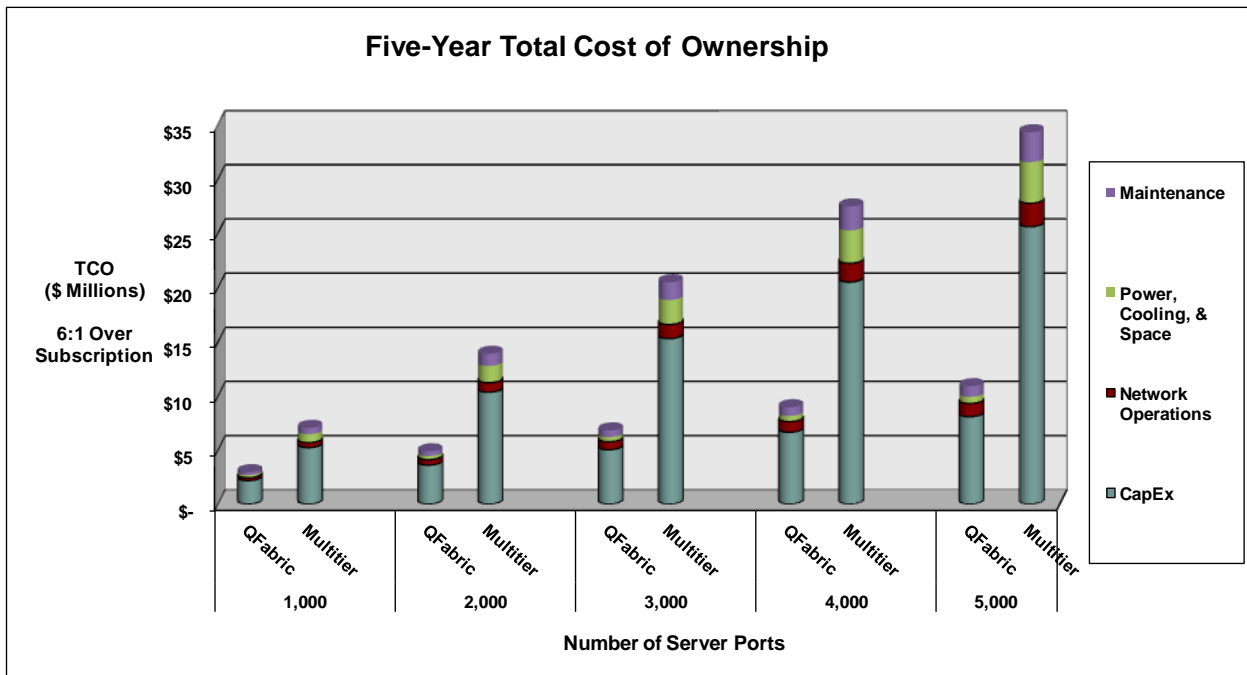


Figure 5 – Five-Year Total Cost of Ownership with 6:1 Oversubscription

The QFabric architecture demonstrates significant TCO advantages over the market leader’s multitier architecture at every port capacity and for both oversubscription ratios. The TCO savings expand as the number of ports increases and as the oversubscription ratio drops from 6:1 to 3:1, illustrating the scaling advantage of QFabric versus the multitier architecture. The scale of operations grows with added ports

and with a declining oversubscription ratio. Therefore, as scale multiplies, the QFabric TCO advantage increases.

The TCO advantage grows with scale because QFabric is able to deliver any-to-any connectivity with fewer chassis and fewer interconnections than the multitier architecture. The reduction of chassis and interconnections leads directly to lower CapEx because fewer switch chassis and line cards are required. This also decreases OpEx because less work is required as the number of chassis and line cards are reduced. QFabric operates as one switch to network operators, and it automates many network operations tasks. OpEx is also reduced because power, cooling and space expenses are lower for QFabric. Power use is the primary driver of power, cooling and space expense.

Figure 6 compares the annual power consumption (KWH) of QFabric versus the multitier architecture. Each column shows the annual power consumption for a specific data center size. The 3:1 oversubscription ratio is the more resource-intensive option analyzed in this study.

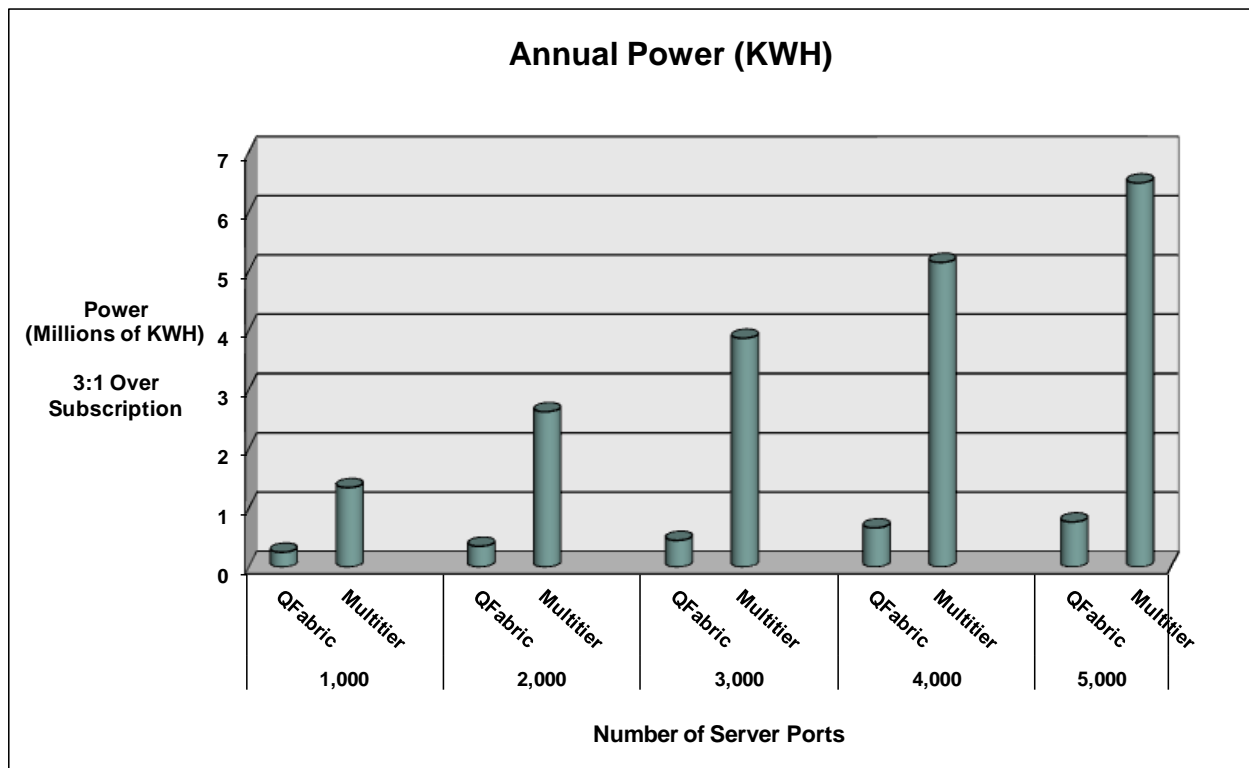


Figure 6 – Annual Power Consumption (Millions of KWH)

QFabric uses power more efficiently than the multitier architecture because it dramatically reduces the number of chassis and interconnections required to provide any-to-any connectivity.



## Conclusion

QFabric is built for scalable data centers. It provides any-to-any connectivity to thousands of end-points. It is a fabric designed to support virtualization, convergence and cloud-ready infrastructure. It has significantly lower TCO when compared with the market leader's multitier data center architecture for two primary reasons:

1. QFabric is highly scalable. It provides any-to-any connectivity with fewer chassis and fewer interconnections than the multitier architecture.
2. QFabric's design and management automation features simplify network operations and the network appears to be one switch to network operators.

QFabric delivers 58% to 76% TCO savings compared to the market leader's multitier architecture. In addition, CapEx is 58% to 75% lower; OpEx is 53% to 77% lower; and power consumption is 68% to 89% lower when compared to the market leader's multitier architecture.

### **ACG Research**

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