THE ECONOMIC BENEFITS OF THE CIENA VIRTUALIZED EDGE SOLUTION

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EXECUTIVE SUMMARY

Over the last decade, enterprise networking has experienced a key paradigm shift with the transition from the deployment of physical network appliances that host specific network functions to the virtualization of those network functions or Network Functions Virtualization (NFV).

NFV systems run a common x86 hardware platform that provides a single physical device that can support multiple virtual applications or Virtual Network Functions (VNFs). The interoperability of those VNFs is enabled by Distributed Network Functions Virtualization Infrastructure (D-NFVI) software. D-NFVI provides a hypervisor, virtual switch, and agent to deliver hosting, orchestrating, and service chaining of those applications or VNFs. Specifically, legacy networks have required enterprises to purchase and maintain multiple hardware appliances for various network functions, such as routers, firewalls, WAN optimizers or Session Boarder Controllers (SBCs). With NFV, these functions can run as software VNFs on the common x86 server, sometimes referred to as Universal Customer Premises Equipment (uCPE). In addition to running VNFs, uCPE edge platforms can run a variety of edge applications on a single high-performance compute server. Examples of edge applications include the Internet of Things (IoT), robot control, and video surveillance. The term virtual edge is used to define an edge x86 server running a combination of VNFs and edge applications on top of D-NFVI software.

Key benefits of virtualization include:

- All network functions share the same uCPE hardware platform
  - Reduces CAPEX
  - Lowers sparing expenses
  - Reduces power consumption
  - Decreases equipment obsolescence
  - Increases operational agility
  - Enables easy deployment of new network functions without hardware installation
- Complete application flexibility to meet ever-changing business requirements: Add applications or exchange for newer technologies without additional capital equipment investment
- A single uCPE device can support multiple network connections for reliability, including LTE/5G backup to provide for high availability
- NFV is well suited to network orchestration and automated management
- VNF software can be scaled up or down to meet branch office requirements

As a result of these benefits, enterprises can realize up to 59 percent reduction in the total cost of ownership (TCO) over five years with the Ciena Virtualized Edge Solution. This paper presents a detailed TCO model and results illustrating the TCO benefits of the solution.

This paper also discusses modern enterprise network and application requirements, provides an overview of legacy networks with physical appliances, and explains the benefits of the Ciena Virtualized Edge solution.

Enterprise Application Requirements

The pandemic of 2020 and the resulting remote work environment demonstrated that scalable and flexible network and compute services are critical to business outcomes for all types of enterprises. Many large enterprises have hundreds or thousands of branch or remote locations and 500 or more applications—and those numbers are growing. Most enterprises depend on applications and network connectivity to support day-to-day operations across locations throughout their business ecosystem, including:

- Enterprise branch offices
- Large corporate offices
- Factories
- Distribution facilities
- Stores
- Outside infrastructure, for example, pipelines and electric power transmission
- Health-care facilities
- Public cloud data centers
- Private cloud data centers

The key requirement for networks is to connect end points to applications and content. Applications can be hosted on remote edge sites, enterprise edge data centers, public cloud data centers, and private cloud data centers. Enterprises have a diverse set of application needs that impact network requirements, including industry-specific and custom applications. Table 1 provides an overview of some typical enterprise applications. For each application, it specifies where edge computing is required and provides an overview of network requirements.

Application	Enterprise Vertical	Edge Computer	Network Requirements
Custom business applications	All	Some applications require edge compute	Security, performance, quality of experience (QoE)
Video meetings	All	No	Security, performance, QoE
Voice	All	SBC required	Security, QoE
Video surveillance	Industrial, healthcare, energy, government, transportation	Yes	Security, video storage and processing
IoT	Industrial, healthcare, energy, government	Yes	Security, latency, IoT edge gateways
Robots and drones	Industrial, energy, government, transportation	Yes	Security, latency, and performance
Augmented Reality (AR) and Virtual Reality (VR)	Industrial, energy, government, healthcare	Yes	Security, latency, and performance
Analytics	All	Yes	Best effort

Table 1. Examples of Enterprise Applications

An edge computing ecosystem is a set of applications that need to be hosted on edge servers, which are near users and end points. Many enterprise applications are hosted in public or private clouds; however, edge applications must be hosted near the user end point because of requirements for latency, network throughput, operational agility or security. For example, some applications such as those controlling robots or drones require extremely low latency; therefore, the robot control application needs to be hosted near the end point to reduce network latency. Another example is video surveillance and facial recognition. To reduce network traffic, edge servers are used for video processing and AI/Machine Learning (ML) applications. Smaller subsets of video data are then transported to the cloud. A virtualized edge solution that virtualizes multiple business applications onto a high-end compute device combined with virtual network functions and multi-cloud integration enabled by D-NFVI software helps enterprises evolve toward an edge compute environment.

Many of the key network services used by enterprises to support applications include:

- MPLS routing
- SD-WAN
- Next-generation firewall
- Unified threat management
- WAN optimization
- SBC
- Wi-Fi (APs and controllers)

These network services are used in conjunction with edge computing and analytics applications to enable the continued evolution of enterprise applications. Key network requirements provided by these services include:

- Security
- High availability
- Optimized application performance
- Visibility, monitoring, and control
- Voice and data support
- Turnkey solutions

Physical Edge

The present mode of operations used in our economic comparison is a legacy network infrastructure with multiple physical appliances. This architecture is referred to as the physical edge. In this comparison, multiple network functions that could be deployed in different parts of the network are considered. The specific network functions modeled are:

- SD-WAN
- Firewall
- WAN optimization
- SBC
- Wi-Fi controller
- Edge compute
- Analytics software

Each network function runs in a separate physical appliance with hardware optimized to run the network function, for example, physical firewalls or physical SBC appliances. Each appliance is provided and supported by a different vendor, and hardware and software cannot be disaggregated. If new services are added, then new physical appliances need to be installed. It is difficult and time consuming to rollout new services because truck rolls and physical installation are required to install a new network function. Separate physical appliances also require additional power and space, and the cost of labor for network operations increases.

Ciena Virtualized Edge Solution

The Ciena Virtualized Edge Solution implements NFV in a uCPE device running the Ciena D-NFVI software. The uCPE uses an x86 general-purpose processor to run multiple VNFs, which are service chained using D-NFVI. In the TCO model, the following uCPE platforms are used:

- Ciena 3906mvi
- Ciena 3926m
- Higher-end open compute platform

Figure 1 illustrates both the physical edge architecture and the Ciena Virtualized Edge Solution. The physical edge architecture requires separate physical appliances for each network function; the virtualized edge uses a common uCPE device to run multiple VNFs.

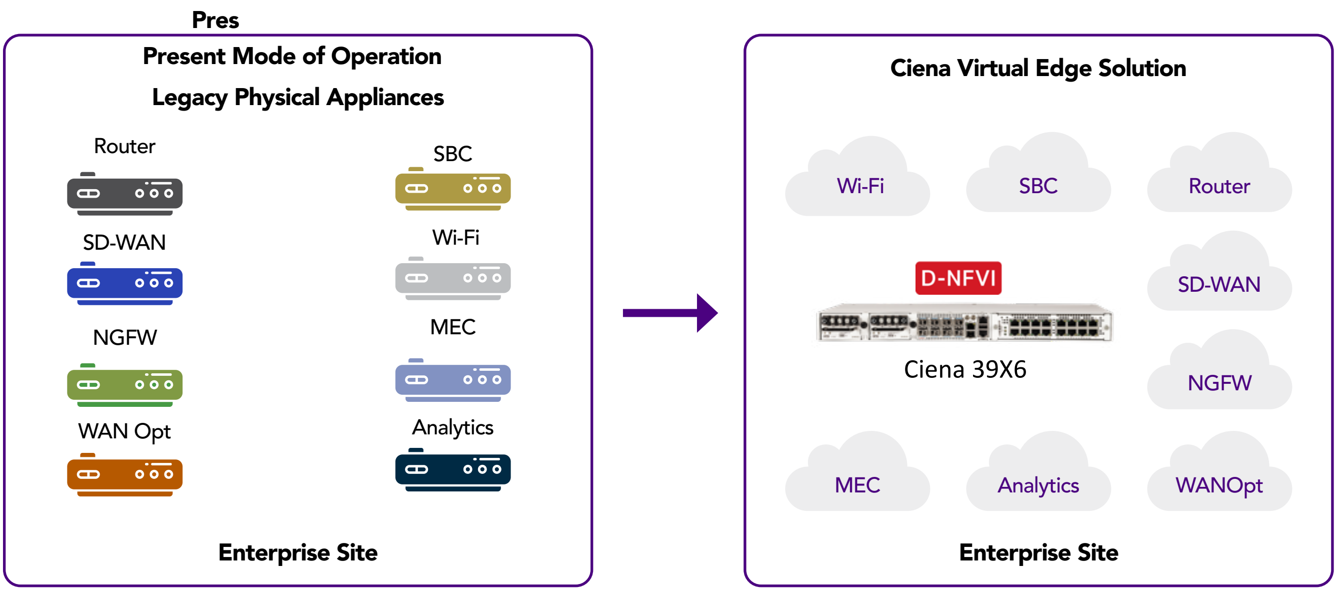

Figure 1. Architecture Comparison of Physical Edge with the Ciena Virtualized Edge Solution

The key to hosting, managing, and operating multiple VNFs in an edge platform is the Ciena D-NFVI software, which is a complete, open, modular solution for VNF life-cycle management. D-NFVI provides a hypervisor with VNF service chaining and has the following components:

- Ciena Base Virtualization OS includes Ciena-supported distribution of a virtualization Operating System (OS) for x86 hardware, which has the base Linux OS, Kernel-based Virtualization Machine (KVM) hypervisor and Linux Container (LXC) support
- Ciena vSwitch provides MEF CE 2.0 functionality by Data Plane Development Kit (DPDK) accelerated vSwitch for service function forwarding
- Ciena D-NFVI Agent provides an OpenStack alternative purposely optimized for the D-NFV use case and is a virtualized infrastructure management solution based on direct orchestration

The Ciena D-NFVI solution allows users to mix solutions from different vendors or on-board any homemade functionality. Ciena already has an extensive list of tested VNFs with multiple partners and a solution ecosystem that continues to realize explosive growth. The Ciena D-NFVI solution is not limited to pretested VNFs and is open to integrate new partners selected by customers.

Ciena D-NFVI key benefits include:

- Uses open software for hosting and life-cycle management of multi-vendor VNFs
- Runs on any x86 platform, which includes the Ciena uCPE and servers from other vendors
- Uses static resource allocation, which ensures that low-priority VNFs cannot steal resources from high-priority VNFs
- Supports direct orchestration of VNF functions at the CPE using industry-standard interfaces to the NFV orchestration and management function
- Offers higher, more fully-featured performance with the Ciena vSwitch, such as sophisticated VLAN manipulations, OAM functions, and complies with MEF CE 2.0 standards

Another key benefit of the solution is the Ciena Services portfolio for life-cycle management. A challenge of NFV is integration, deployment, and troubleshooting of systems with multiple VNFs from multiple vendors. Ciena takes end-to-end responsibility for service and support, providing enterprises with a single point of contact. Ciena leverages experience working with multiple vendors, technologies, and systems to provide best-in-class service and support for enterprises. The Ciena Services portfolio consists of:

- Solution design
- Solution implementation
- Service deployment
- Managed operations
- Solution support
- Life-cycle management

TCO Model and Assumptions

ACG uses its Business Analytics Engine (BAE) platform to model application, data center, and network economics. ACG has developed a custom tool using the BAE to model the Ciena Virtualized Edge Solution. This tool can be customized to model a specific enterprise customer's network.

A five-year TCO model forecasts the total CAPEX and OPEX of edge services. The model compares the physical edge using legacy physical appliances with the Ciena Virtualized Edge Solution using D-NFVI software and full life-cycle system integration services. There are three primary types of inputs to the model, which are represented in Figure 2:

- Network architecture input assumptions
- Unit expense input assumptions
- OPEX input assumptions

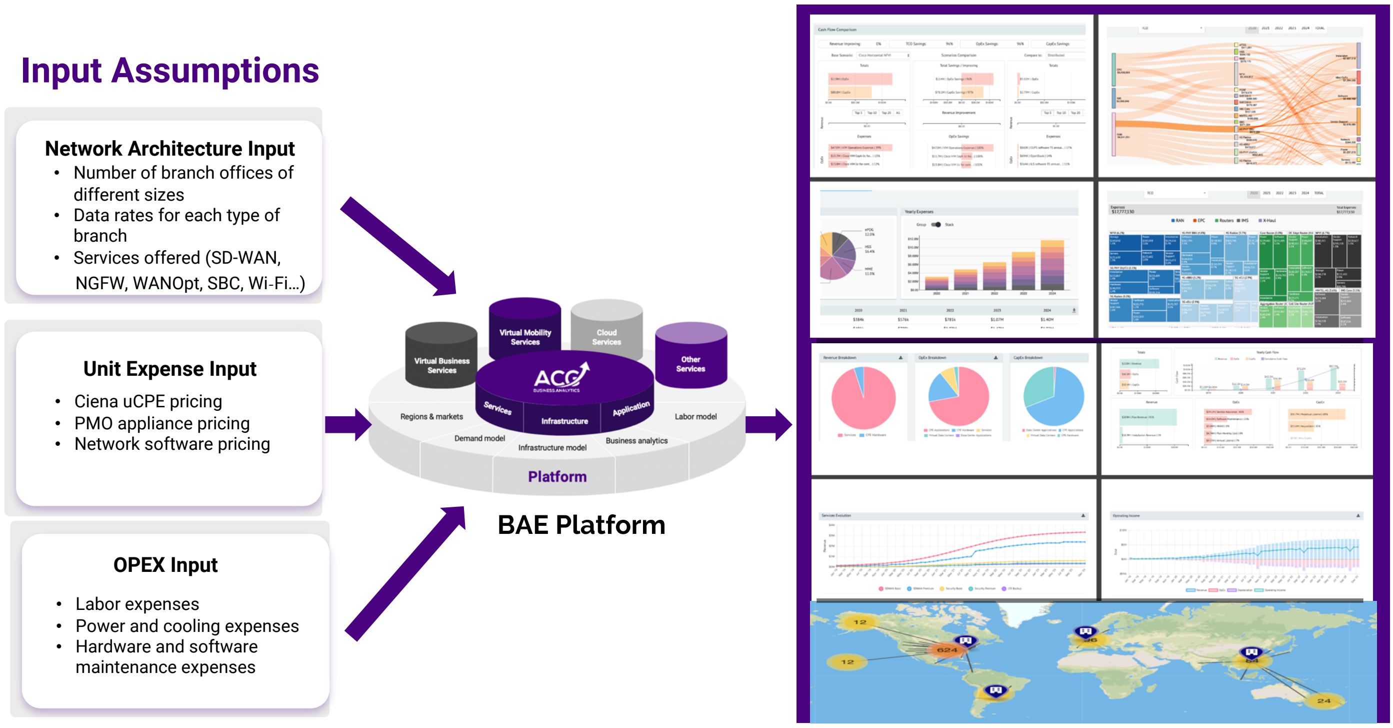

Figure 2. Input Assumptions and ACG BAE Model of the Ciena Virtualized Edge Solution Using 39X6 uCPE

[1] https://www.acgcc.com/p/bae-software/

The model assumes a large enterprise network with 1000 small 100 Mb/s sites and 10 large 1 Gb/s sites. Sites can use a high-availability option that provides redundant uCPE devices. In a high-availability site, uCPE hardware is replicated, but the cost of redundant VNF software is typically lower than the cost of a stand-alone VNF. The assumptions for the number of sites and the distribution of VNFs at sites is presented in Table 2. It is assumed that the high-availability architecture is used in all the large 1 Gb/s sites but only in 20 percent of the lower-speed 100 Mb/s sites. It is also assumed that an SD-WAN router VNF and firewall VNF are used in all sites, but other VNFs are used at a smaller percentage of the sites. A final assumption is that the Ciena system integration services are used for solution design, implementation, service deployment, support, and life-cycle management.

Enterprise Category	# Sites	High Availability	SD-WAN Router	Firewall	WAN Opt	SBC	Edge Computer	Wi-Fi	Analytics
Small 100 Mb/s Sites	1000	20%	100%	100%	50%	50%	20%	20%	10%
Large 1 Gb/s Sites	10	100%	100%	100%	50%	50%	20%	20%	10%

Table 2. Number of Edge Sites and Distribution of VNFs at Sites

TCO Results

A high-level summary of the TCO results is presented in Table 3 and Table 4. For the network previously described, the results show a TCO savings of 59 percent.

Expense Type	Virtual Edge Savings
CAPEX	59%
OPEX	57%
TCO	59%

Table 3. Five-Year Cumulative Ciena Virtualized Edge Solution TCO Savings

Expense Type	Virtual Edge	Physical Appliances
CAPEX	$20.7M	$50.2M
OPEX	$2.45M	$5.73M
TCO	$23.1M	$55.9M

Table 4. Five-Year Cumulative TCO Comparison of Virtual Edge and Physical Appliances

A year-by-year TCO comparison of the physical edge and the virtual edge is presented in Figure 3. As the network grows and new sites and network functions are added, the difference between the physical edge TCO and the virtual edge TCO continues to grow.

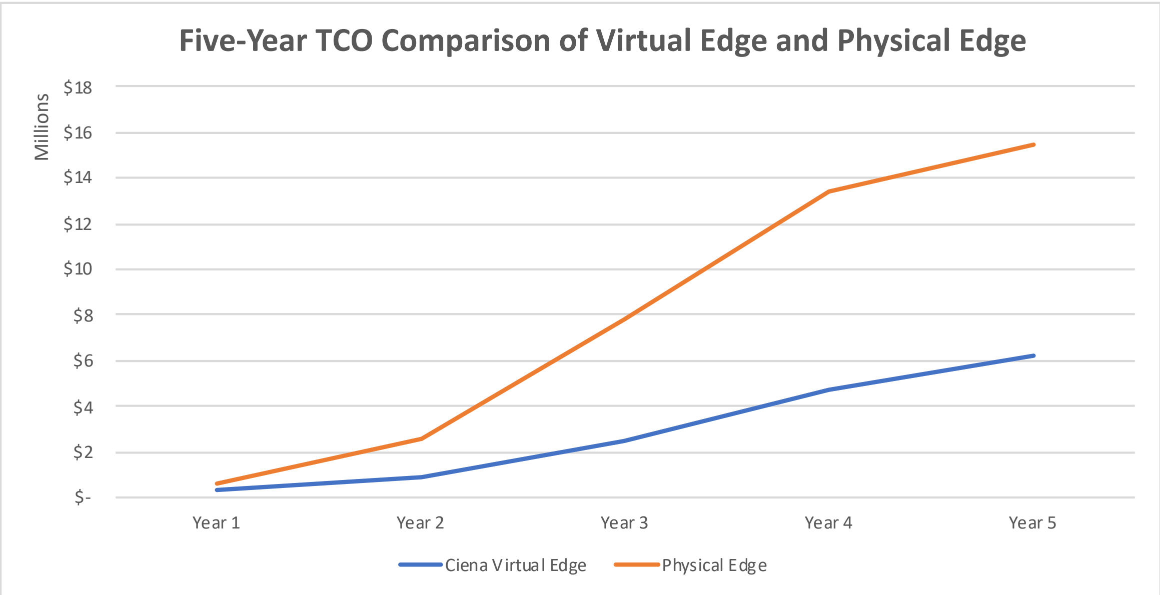

Figure 3. Five-Year TCO Comparison of the Virtual Edge and the Physical Edge

A breakdown of the cumulative five-year CAPEX and OPEX is presented in Figure 4 and Figure 5. The breakdown shows the top 10 components illustrating the main drivers of the TCO. This analysis clearly shows that the TCO savings is driven by using a common uCPE hardware platform hosting multiple VNFs versus and installing multiple physical appliances for each network function.

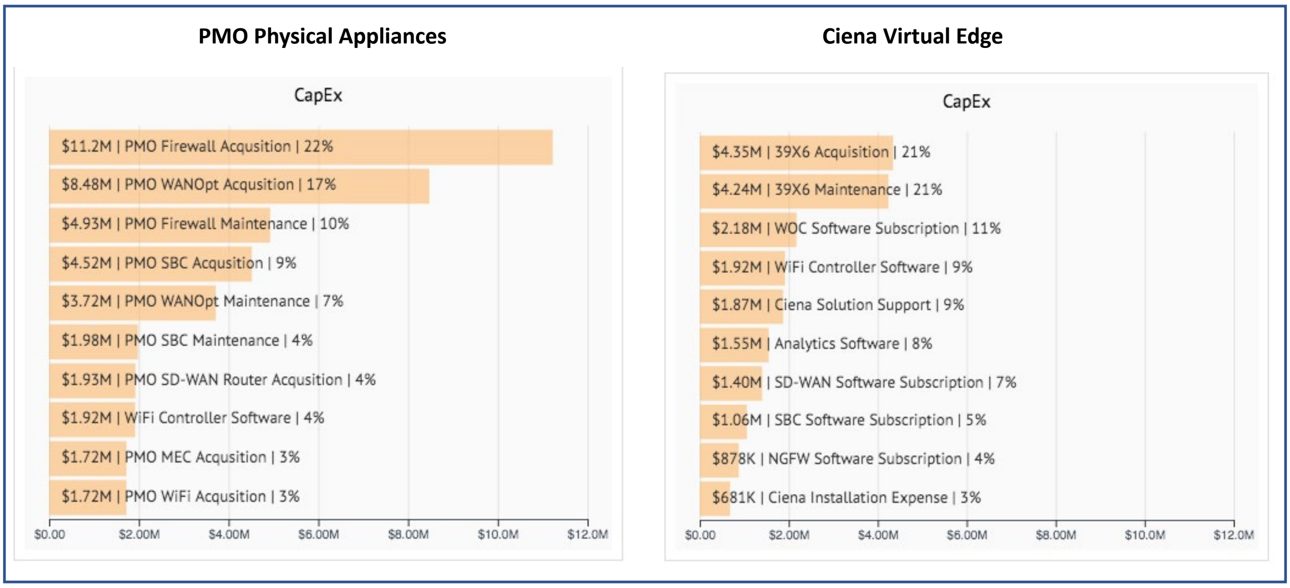

Figure 4. Five-Year Cumulative CAPEX Breakdown of Physical Edge and Virtual Edge Top 10 Components

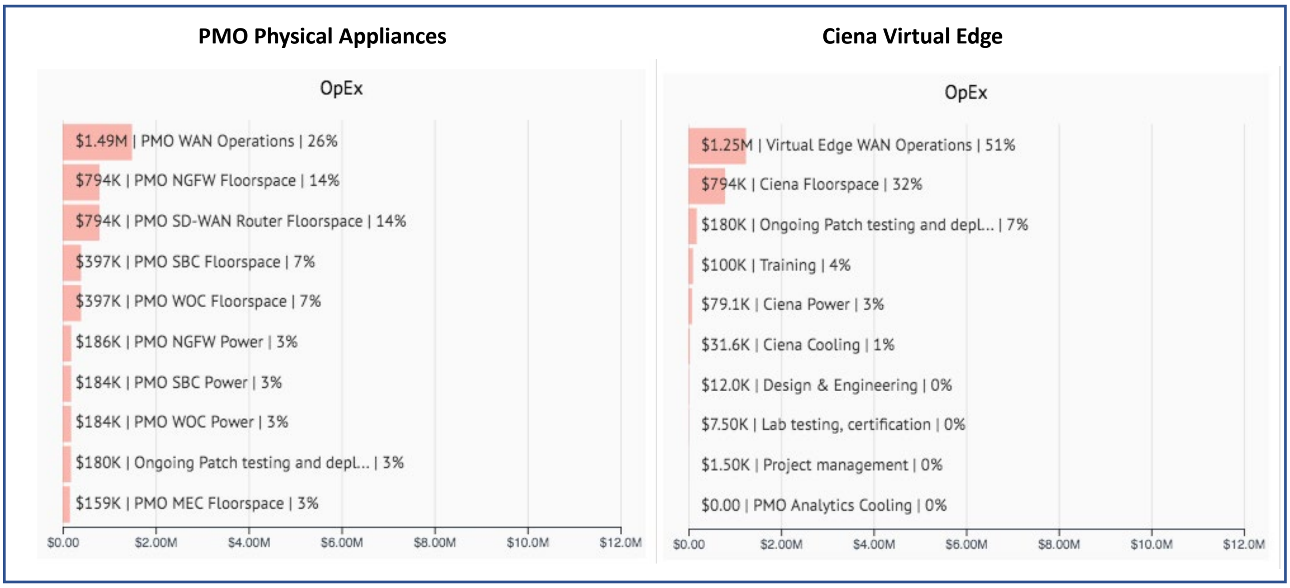

Figure 5. Five-Year Cumulative OPEX Breakdown of Physical Edge and Virtual Edge Top 10 Components

Move to the Virtual Edge

In addition to the total cost of ownership savings, enterprises can achieve significant operational benefits by evolving from a physical edge infrastructure to a virtual edge infrastructure. Key operational benefits that enterprises have achieved across multiple industry sectors are summarized in Table 5.

Physical Edge	Virtual Edge
Systems are closed and proprietary.	It is hosted on open x86 based hardware.
Separate physical appliances are required for each network function.	A single Ciena 39X6 with D-NFVI can host all virtual network functions.
New service provisioning requires a truck roll and physical configuration and testing of an appliance on site.	New services can be deployed remotely using orchestration and automation. Truck rolls are not required.
Modern network orchestration systems are not well suited to managing physical appliances.	Most orchestration systems can natively manage virtual network functions.
Automation is more difficult to implement and maintain in physical appliances.	Automation is a key component of NFV.
Physical appliances have fixed capacity and changes in capacity require replacing the appliance.	Virtual network functions can be scaled up or down on demand.
Physical appliances consume more power than virtual appliances.	Virtual network functions share a common hardware platform and consume less power as a result.
Inventory and sparing are complex when many physical appliances are required.	A common Ciena 39X6 platform simplifies inventory management and sparing.
Physical appliances result in higher TCO.	A virtual edge provides TCO savings of up to 59%.

Table 5. Key Benefits of the Virtual Edge Architecture

NFV has shifted the paradigm of networking from fixed hardware-based appliances to VNFs hosted on standard x86 servers. The Ciena 39X6 with D-NFVI software is an example of an open, x86 based virtual edge platform that provides enterprises with a flexible environment for offering services. The virtualized edge has significant TCO benefits over the physical edge.

Ciena's Virtualized Edge Solution
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