White paper

vCPE Evolution Path

Driving agility, cost-efficiency, and operational excellence with NFV-powered vCPE solutions

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Executive Summary

The move to the cloud from private data centers has shifted the role of business services towards assured data center connectivity. These services face intense cost pressure but, since they form the lifelines between enterprises and business-critical infrastructure, QoS cannot be sacrificed.

Cost savings and service agility are being realized by leading service providers virtualizing as many customer premises appliances and functions as possible, making the vCPE a critical component in a competitive connectivity delivery model. The logical extension of network function virtualization (NFV) is applying this approach to the vCPE, which itself minimizes the last remaining customer premises hardware required.

This major transformation is occurring at the same time the vCPE is becoming an ever more critical component in the service delivery path and its lifecycle. The migration to NFV is inevitable, but doesn't have to be painful. The best approaches unify a variety of programmable vCPE options, while benefiting from the extensibility and cost benefits realized by orchestrated virtualization implemented in an open, real-time architecture.

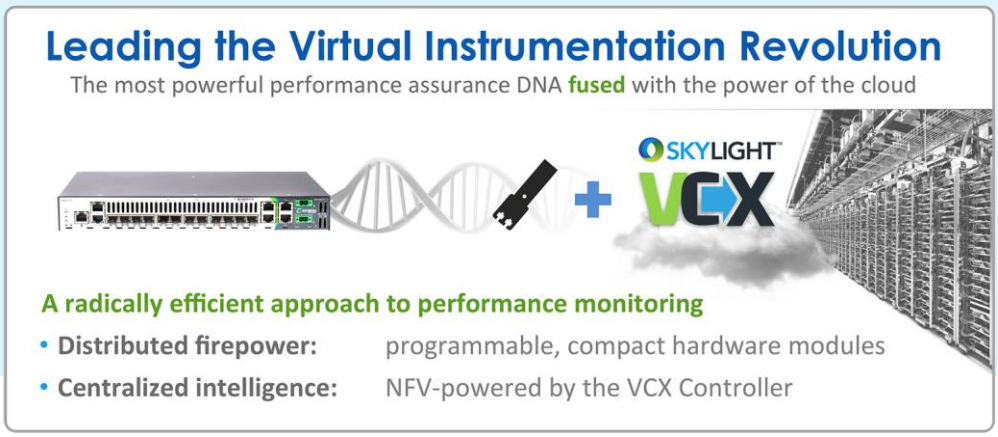
This paper covers the trends behind the changing role of the vCPE, the capability sets they require, and the diverse range of performance assurance applications that will emerge from their transformation to NFV-based appliances.

March 2015

A Seismic Shift in Connectivity

As traditional business services shift towards federated cloud connectivity, cost pressures demand a customer premises equipment migration strategy that embraces virtualization to deliver network performance without compromise. Data center, cloud compute, and leading communication service providers (CSPs) have set a new course for the methods and equipment that will deliver these critical connectivity services, in turn offering exceptional value to their customers.

Accedian's SkyLIGHT™ Performance Platform was designed from the ground up as a radically more efficient way to deliver, monitor, and assure enterprise-to-cloud connectivity. Its highly programmable, open architecture revolves around virtual network functions (VNFs) that bring scalable, extensible service assurance capabilities to software and hardware Performance Modules. The result is complete quality of service and experience (QoS and QoE) visibility from enterprise IT closet to virtual-machine, and all key points in between. SkyLIGHT offers a network-wide, carrier-grade, network embedded solution that combines distributed firepower with centralized intelligence, redefining performance monitoring and optimization in step with the dynamic networks and services cloud connectivity demands.



Full test set functionality in the smallest possible form factor.

Beyond Loopbacks

SAT

wire-speed traffic generation

Beyond Reflectors

PM

full mesh, bi-directional performance monitoring

Beyond Counters

BW

per-flow bandwidth utilization

VIRTUALIZE NO COMPROMISE

NFV and the Cloud-Enabled Enterprise

As the ETSI[1] NFV working group closes phase one of their mandate, the architecture, infrastructure domains, management, orchestration, security, and resilience requirements of NFV have been broadly defined and accepted. In response to successful proof of concept (POC) deployments worldwide, one of NFV's most proven and promising first use cases is now seeing widespread adoption: virtualized customer premises equipment[2], or vCPE.

NFV presents an opportunity to replace racks of customer premises equipment (CPE) with centrally managed software, driving cost, complexity and static services out of the equation. Successful vCPE strategies focus on virtualizing as many functions as practically possible, while retaining the minimum CPE required to establish and assure service performance. In this context, the remaining CSP presence at the customer site–whether a software agent or minimum form factor hardware–is often itself referred to as a vCPE[3].

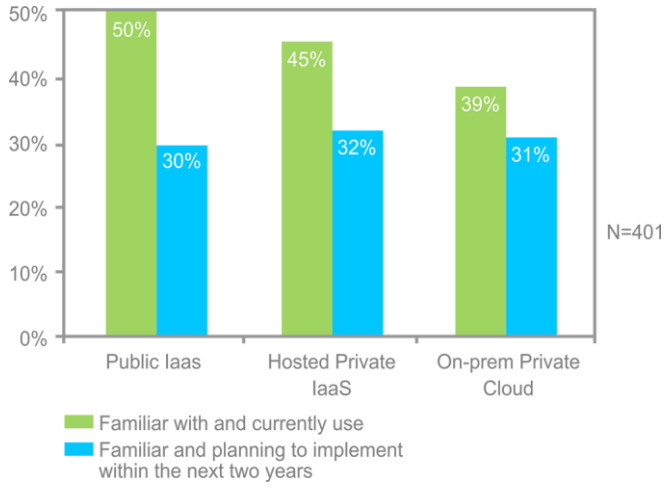
Accedian Networks is a 10 year innovator of intelligent network interface devices (NIDs) that evolved into full-fledged Performance Elements, today assuring hundreds of thousands of connections, and installed as vCPE in leading CSP networks as early as 2011. With over 40 patents in performance assurance, Accedian's leadership is based on in-depth networking knowledge and hands-on experience supporting over 350 service providers worldwide annually. Development efforts are focused directly on customer needs, and built on the fastest programmable technologies available. SkyLIGHT is the platform Accedian will build on to continue this pace of innovation for years to come.

[1] European Telecommunications Standards Institute
[2] Equipment: in the plural sense
[3] For the remainder of this document "vCPE" will be used as a generic term that refers to CSP hardware at the customer premises, acting as the service demarcation point and performing related functions.

vCPE - Great Expectations

CSPs, margins, and revenues are being threatened from all sides. Public cloud platforms, over-the-top (OTT) wide area networking (WAN) technologies, cheap, dumb pipes, and customers' shifting focus from networks to the applications they carry appear to commoditize their offerings. However, as enterprises increasingly migrate to public and private clouds, the connectivity to these hosted resources becomes ever more critical to their business success. It's their lifeline to the cloud. In 2014, 70% of Fortune 500 enterprises employed private cloud data centers, and by the end of 2015 the same proportion is expected to employ hybrid (private with public) cloud services[4]. Of those planning to adopt public cloud services into their infrastructure, 32% cite connectivity performance concerns as their biggest barrier to adoption, followed by 22% worried about about provider service level agreement (SLA) accountability.

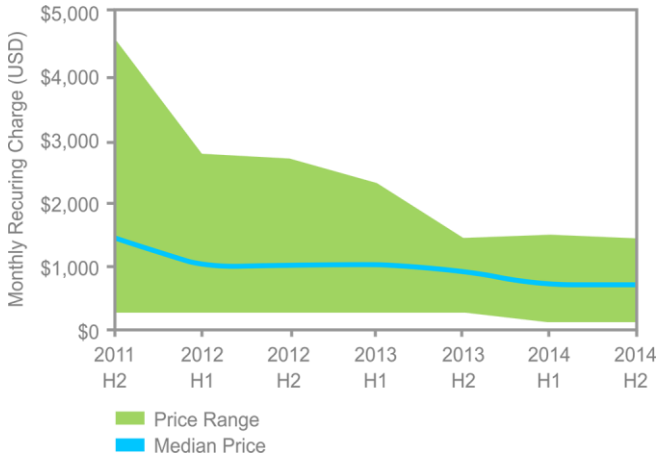
Enterprise Cloud Adoption



Enterprise private & public cloud adoption is quickly becoming the new norm (Frost & Sullivan, 2014)

This trend translates into a clear message for CSPs: deliver performance assured multi-cloud, multi-service connectivity as cost-effectively and flexibly as possible.

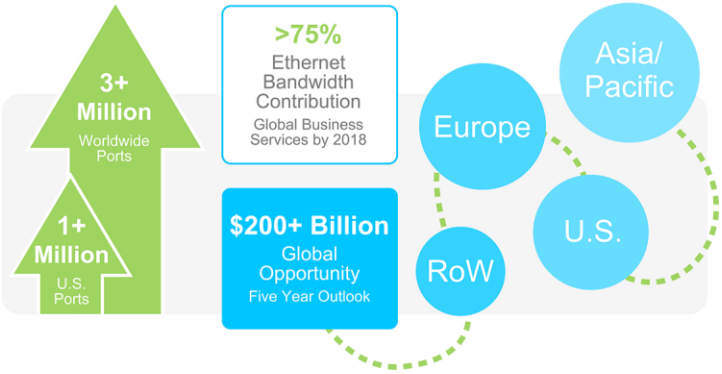
European GbE Services Pricing



Connectivity price pressure trends are evident (Telegeography, November 2014)

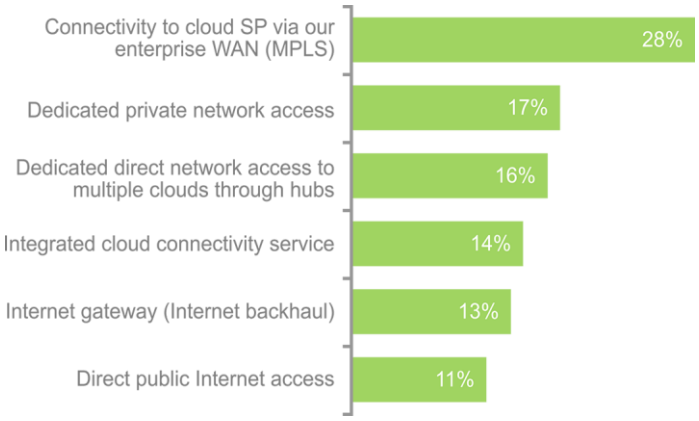
[4] Gartner, November 2014

Worldwide Carrier Ethernet Services



The opportunity is significant for CSPs who adapt to a new delivery reality: agile and cost-efficient (Vertical Systems Group, November 2014)

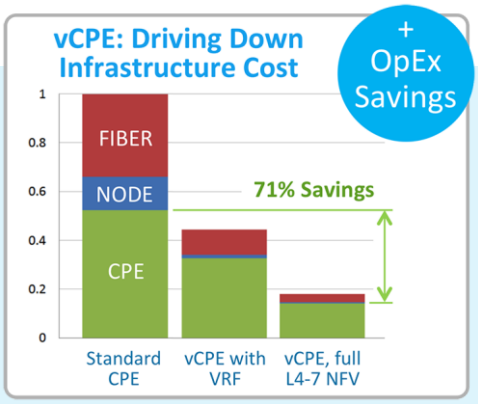
Just as the public cloud redefined the cost of compute, CSPs can redefine the cost and time required to deliver their services by employing a vCPE strategy that evolves along with their customers' needs to ride this new wave of ubiquitous connectivity. Despite a range of competitive alternatives, large enterprise are largely turning to their trusted CSPs for connectivity, with less than 25% using internet-based methods to reach hosted resources.



Enterprise cloud connectivity breakdown (IDC, October 2014)

Accedian Networks is the primary supplier of vCPE solutions to Colt Technology Services, who quantified the benefits of these solutions after tens of thousands of units were deployed over a three year period. The introduction of a cost efficient vCPE with powerful Operations and Maintenance (OAM), Layer 3 performance monitoring and H-QoS features helped Colt virtualize onsite routers to realize over 70% savings in capital spend[5], with added savings in operational expenses and future savings secured by a broad NFV strategy that all but eliminates on-premises appliances.

This early involvement in one of the first large-scale vCPE deployments was pivotal to the evolution of Accedian's long-term vCPE strategy.



Source: Colt Technology Services, SDN & OpenFlow World Congress, Oct. 2014

For a complete overview of Accedian's market-leading, multi-tenant and NFV-powered vCPE solutions please see our white paper, "vCPE, Performance Assured," available at Accedian.com/library

[5] as reported in October 2014

The vCPE Journey - From Standalone to NFV-Based

Many vCPE deployments use Performance Elements (intelligent NIDs) to perform critical customer premises edge functions like Layer 2 and 3 QoS mapping, hierarchical traffic conditioning, service OAM, and performance monitoring, allowing routing and other L3+ functions to be located and/or virtualized deeper into the network. While this approach is still a highly cost-effective method to deploy services in a multi-tenant environment, unit cost can lengthen return on investment (ROI) when serving a single customer.

Accedian Nano smart SFP module installed as vCPE, and the GbE ant Module

By deploying NFV-enhanced modules as vCPEs (e.g. smart SFPs / compact GbE modules), CSPs can more cost-efficiently deploy services without compromising the hardware-based performance and full functionality offered by standalone vCPEs. Increasingly, leading CSPs are adopting this approach to:

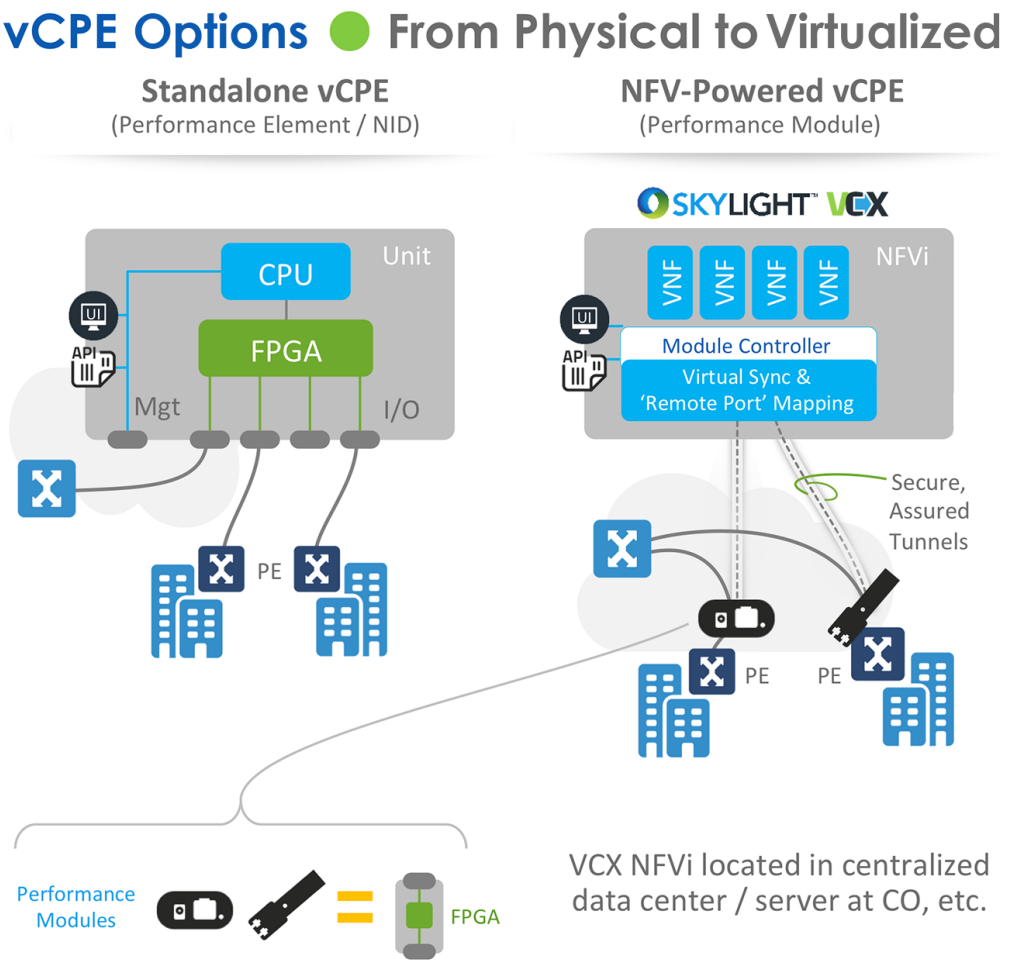
- Realize significant savings in capital and operational expense
- Increase performance visibility
- Greatly decrease deployment time with customer self-install capabilities
- Outmaneuver competitors with higher cost structures
- Compete on performance, not price

NFV-based vCPEs offer the advantage of significant scalability, central programmability, and simplified feature enhancement with simple software upgrades to the module controller's VNF catalog.

Accedian offers a range of Network Performance Elements as standalone vCPEs for multi-tenant sites, as well as programmable SFP and GbE modules with the same full feature-set when employing VNFs powered by the SkyLIGHT VCX Controller.

Right-Sizing vCPE for Full Network Coverage

By breaking down the standalone vCPE into its logical components, various NFV-based implementation options emerge. This allows the CSP to employ a variety of variants to address site-specific requirements while retaining unified control and visibility over all service endpoints.



A full range of deployment options are available with NFV-powered virtualized instrumentation, modules replicating standalone vCPE functionality cost-efficiently.

Regardless of embodiment, vCPE functions remain the same while the logical building blocks become distributed and software-enhanced. Here is how standalone vCPE functions map to their virtualized counterparts:

CPU Functionality

Standalone vCPE	NFV-Powered vCPE
Connection, performance monitoring, service activation session, security, accounting, results processing, interface to external systems (CLI or API).	Becomes virtualized and orchestrated in a platform that breaks separate functions into VNFs sharing a common automation, accounting, and data storage architecture.

Packet-Level Processing Functions

localized at the service demarcation point, physical or virtual

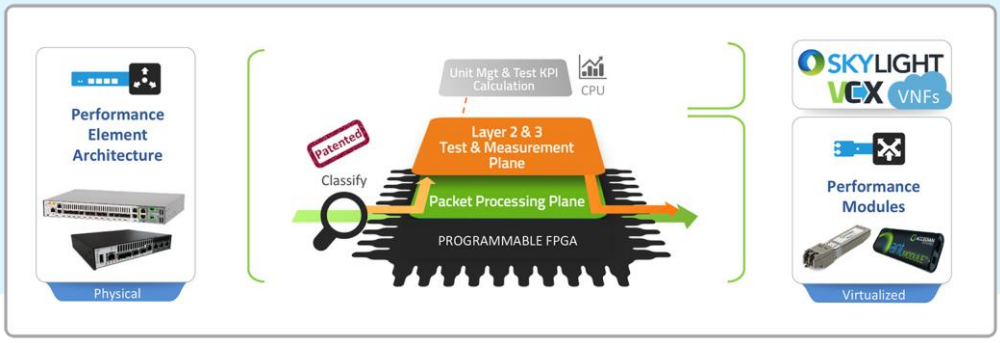
Standalone vCPE	Hardware Module Variant (vCPE)
Test and measurement, and data processing in dual-plane FPGA architecture ensures near-zero latency pass-through performance while providing consistent, precise assurance functions at any line rate.	Hardware-related functions are retained in a programmable FPGA in miniaturized modules to ensure performance is not compromised. Computation or results processing is split between local processing and VNFs to keep module cost, size and power requirements as low as possible.

Ports

Standalone vCPE	Hardware Module Variant (vCPE)
Test directly connected to the packet processing and CPU resources in a manner optimized for packet handling and test and measuring functions at full wire speed. Various port rate, count and media options are available for single-site, multi-tenant and network to network interface applications. Management conducted in or out of band.	Modules offer two active local ports (in / out) for inline or out-of-line installation. Modules may feature a number of ports for media / rate conversion, but only two selected ports are active when deployed. Ports are directly connected to the programmable FPGA for > 1PPM processing speeds. Where multi-port / multi-tenant functionality is required, additional modules can be used as separate 'remote ports' as managed by the module / VNF controller. Management can be conducted in or out of band.

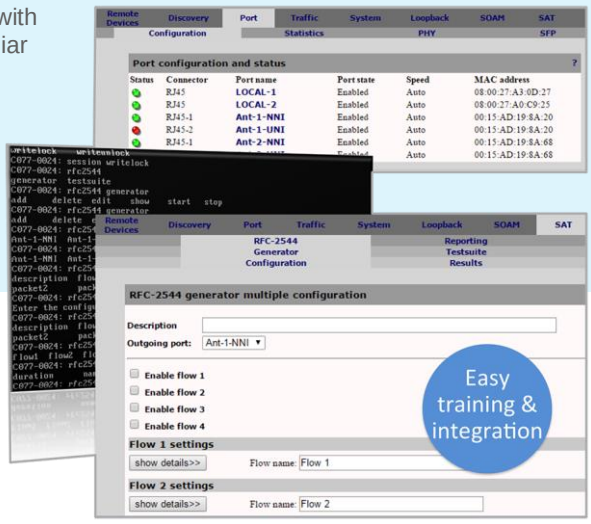
Leading the Virtualized Instrumentation Revolution

Accedian Networks' SkyLIGHT VCX Controller assumes "CPU functionality" for thousands of Performance Modules, each of which becomes a "remote port." The VCX maintains synchronization information for each endpoint, permitting highly precise one-way measurements over a variety of remote locations. The Module's integrated FPGA can perform SAT, OAM, performance monitoring, and many other performance assurance and traffic conditioning functions under the control and command of the VCX. Accedian's patented dual-plane packet processing architecture is retained in the Module design, allowing these miniaturized devices to generate full line-rate test traffic, and maintain thousands of performance monitoring / OAM sessions per unit. The result is the equivalent functionality of Accedian's award-winning Performance Elements, in the smallest possible form factor, at a fraction of the cost.



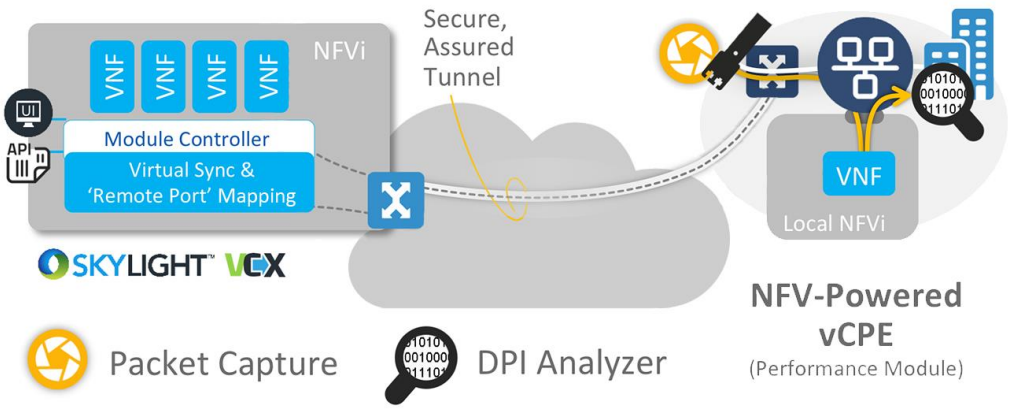
Modules become the data plane extension of the VCX Controller, which otherwise appears to the CSP as a single Performance Element with each port representing a deployed Module instance. The web interface, CLI, and other attributes are nearly identical to Accedian's standalone vCPE, simplifying the migration to virtualized Modules and ensuring uniform management of mixed deployments.

Logging into the VCX, or controlling it with Accedian's proven CLI, provide a familiar experience to CSPs used to deploying standalone vCPE hardware.



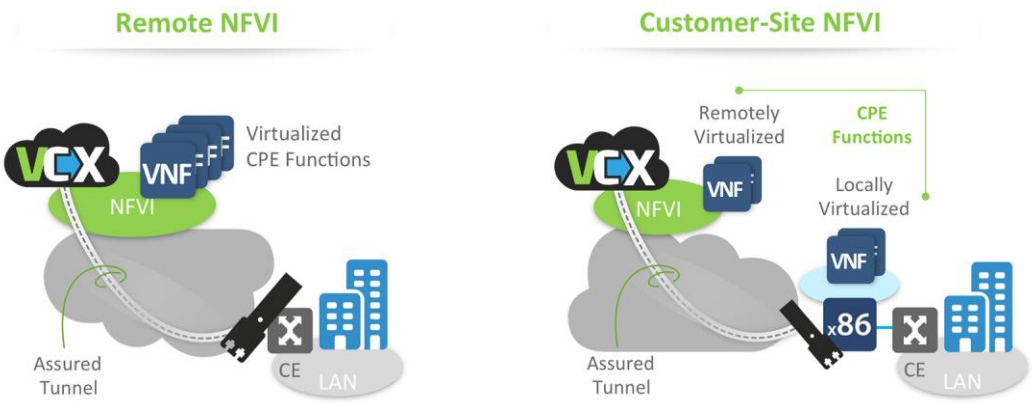
VNF Localization

Whether the vCPE is physical or virtual, the ability to host and move VNFs to diverse locations needs to be supported by an effective NFV-powered vCPE solution deployment strategy. Strategically localized VNF processing can relieve network bandwidth and lower VNF latency. As an example, hosting a remote packet capture VNF as close as possible to a target Deep Packet Inspection (DPI) appliance keeps related traffic from having to traverse the CSP network.



(NFVI, see sidebar)
VNF hosting locations need to reflect their application and complementary infrastructure to realize the lowest-possible network overhead and ensure efficient processing and distribution

VNFs related to service delivery may extend beyond performance assurance functions to include additional network functions 'chained' together to meet per-customer requirements–from encryption to firewall, local control functions (e.g. wireless network controllers), load balancers, IP PBX, and more. To meet performance requirements, VNFs may need to be located separately. As networks become more dynamic, moving VNFs to scale them up or out, or to increase responsiveness, becomes essential.



VNF deployment options include centralized or on-site hosting, or a mix of each

To learn more about VNF localization considerations–when to deploy on NFVI at the customer premises vs. large scale data centers and points in between–please see our "vCPE, Performance Assured" white paper at Accedian.com/library

NFVI

Network Function Virtualization Infrastructure (NFVI) is a term that refers to the compute resource(s) dedicated to hosting VNFs, ranging from standalone machines and x86 cards in network elements to private or cloud data centers, provided either by customers, the CSP or a third-party.

NFV-Based Architectures for vCPE Evolution

The main goal of vCPE strategies is to use NFV to replace as much equipment as possible at the customer premises with virtualized equivalents in order to reduce CapEx and increase agility.

Continuing this thought to its logical conclusion, it stands to reason that NFV should also be applied to the vCPE "appliance" itself–to further reduce the provider's on-site presence to the minimum possible footprint, while retaining all critical vCPE functions. This is best designed into a layered architecture that abstracts orchestration, control and data plane functions so that solutions are highly extensible, scalable, and programmable, and openly interoperate with other platforms and functions.

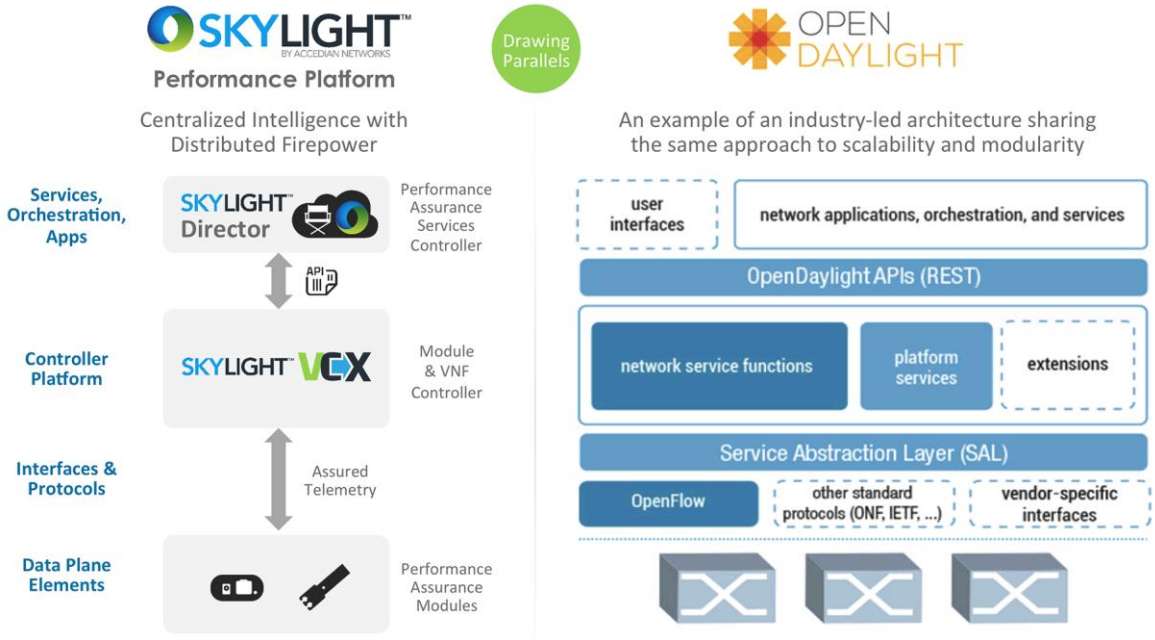
It is along this line of reasoning that Accedian is migrating its solutions from physical to virtualized instrumentation, leading a disruption in the status quo by redefining the cost structure and capabilities available in the vCPE and performance assured networking solutions.

Open, Unified Orchestration Architecture

SDN Architecture Parallels

Software Defined Networking (SDN) offers a proven, standards-based architecture for building centrally controlled, highly-scalable distributed networking fabrics. Separating control from data plane functions greatly reduces the need for powerful networking hardware, replacing it instead with low cost, programmable flow-processing devices that can easily adapt as network and application needs evolve.

The Open Daylight SDN specification defines this approach within a tiered architecture. Data plane elements communicate through a service abstraction layer that frees the network and platform requirements from physical or virtual network implementation details, while a RESTful open API layer interfaces network control with applications and orchestration functions that 'program the network' to dynamically fulfill service requirements.



Accedian's SkyLIGHT Performance Platform employs an analogous approach to redistribute performance assurance components into a highly scalable, open, programmable real-time architecture that retains full interoperability with standalone vCPE and multi-vendor networks. Open APIs at the orchestration and control layers permit flexible points of integration into third party and CSP-developed network management systems (NMS), business operations support systems (B/OSS), SDN controllers, and other platforms, while offering a straightforward migration path from physical to virtualized vCPE.

SkyLIGHT Architecture

The Accedian SkyLIGHT Performance Platform consists of four main layers:

Data Plane:

performance assurance and vCPE functions processed at the service demarcation point by programmable hardware modules, and standards-based PM reflectors.

Protocol:

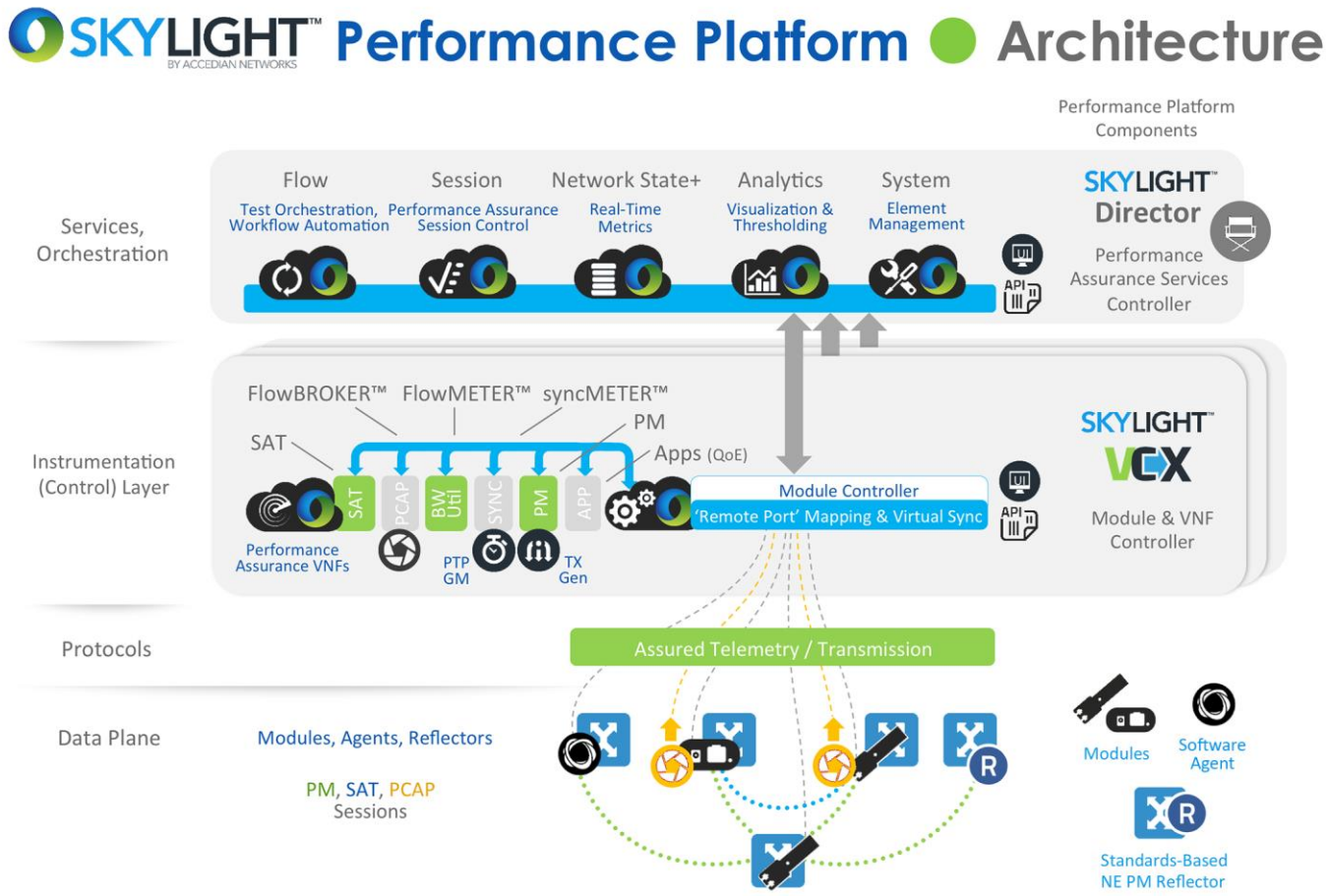
a lossless telemetry method provides an assured, secure 'tunnel' to modules, carrying control and synchronization messages, as well as VNF-specific traffic and metrics for results processing.

Instrumentation (Control):

the SkyLIGHT VCX hosts performance assurance VNFs (for SAT, PM, distributed remote packet capture, and more), as well as module control functions. Virtual synchronization maintains clock offsets for all Modules to allow precise one-way delay measurements. The VCX and its managed Modules can be accessed using traditional CLI commands or a web-based user interface, in addition to being orchestrated by the platform Director. When accessed directly, the VCX appears the same as a standalone vCPE, with each Module represented as a remote port. This allows seamless integration into existing vCPE deployments with the same tools and procedures used with standalone units.

Services & Orchestration:

the SkyLIGHT Director controls multiple VCX appliances (physical or virtual), with modules for test session setup, orchestration, automation, visualization and reporting, and element management. Each Director component interoperates to realize highly dynamic performance assurance functionality, while offering open, integrated access to Network State+ real-time metrics. A common, RESTful northbound interface (NBI) allows other platforms to operate and interact with the platform programmatically.

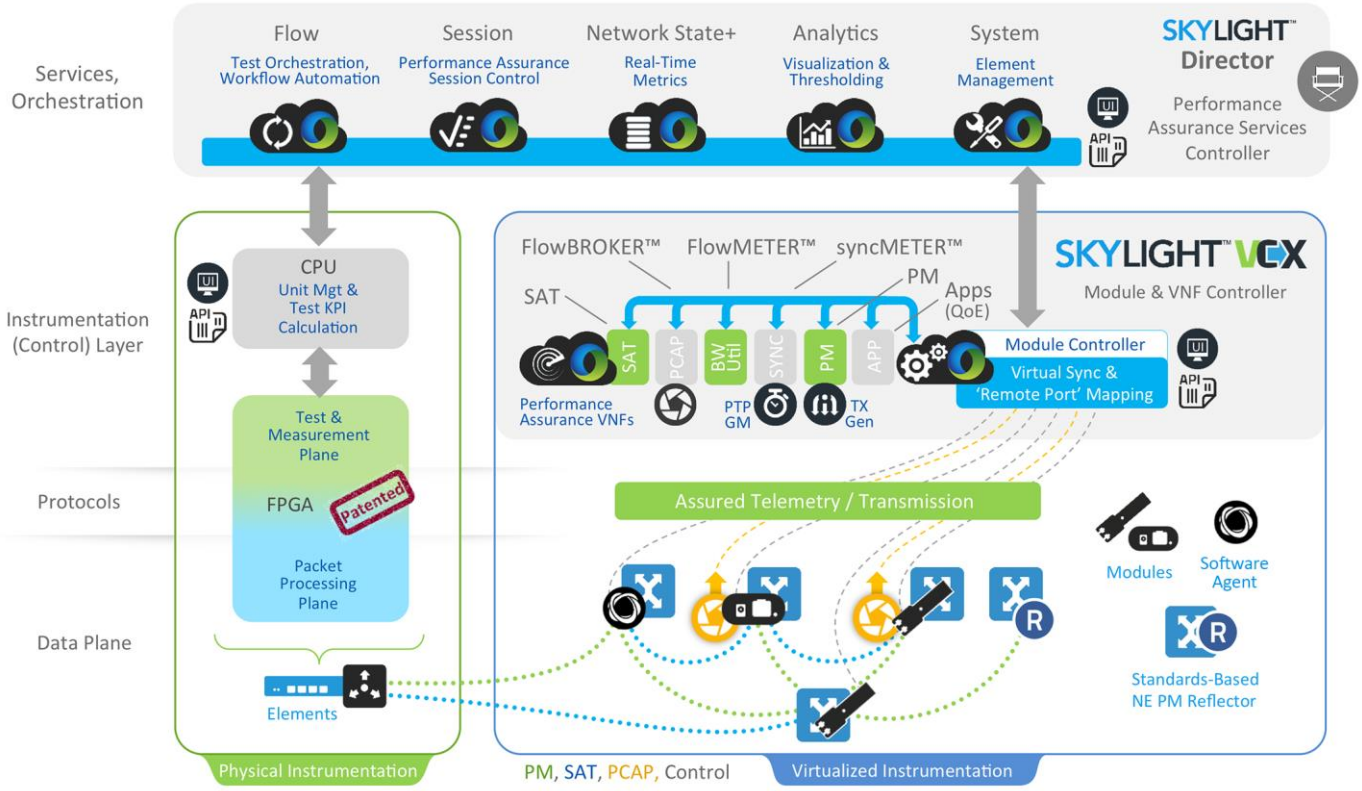


Harmonized Physical & Virtual Instrumentation

Commonly cited wisdom: the customer doesn't care how you deliver a service, they just want the results.

Likewise, CSPs shouldn't have to manage their standalone, NFV-based and vCPE separately. They should seamlessly interact. They should all play their role and produce the required results without special considerations to the method used to realize them. VNFs should appear the same as the standalone appliances they replace, but with added agility, flexibility, and cost-savings.

The Accedian SkyLIGHT Performance Platform fuses together management, orchestration and automation functions for both physical and virtualized vCPE variants, providing a single open API as well as a "single pane of glass" interface to rapidly configure, automate, and visualize network performance assurance between diverse endpoints. This approach puts the focus on quality of service (QoS), and customer quality of experience (QoE) where true value is generated.



Cost and Efficiency Benefits

Accedian's NFV-based vCPE help CSPs realize significant operational and capital efficiencies while offering extended service differentiation compared to legacy approaches.

Operational Benefits:

Dramatic Reduction in Deployment Effort and Expense

- Without equipment to rack, power, and configure, "pluggable" Modules can be customer self-installed with instructions simpler than connecting a cable modem–no truck rolls required, simplified remote customer care, greatly reduced human error.
- Plug & Go™ zero-touch auto-discovery, service activation, and provisioning works over all existing Layer 2 and 3 networks, and all common addressing schemes, including

DHCP assigned and dynamic IP addresses. Modules also feature a patented IP-agnostic mode that "reuses" the IP address of a connected device.

Automated, Multi-Service Activation Testing

- Auto-discovery can trigger immediate, bi-directional turn-up testing directly between service endpoints to create a precise service "birth certificate" and SLA benchmark. Fully automated RFC-2544 & Y.1564 test suites assure conformance with Carrier Ethernet and Layer 3 service attributes. Service activation tests can also be scheduled to execute during maintenance windows, if desired.
- Turn up testing follows the actual service path, and employs distributed traffic generation that allows tests to be conducted at any time of day without impacting the network more than the customer traffic itself would. In addition to service validation, this also permits network readiness assessment for new services.

Real-Time Visibility Into Ongoing Service Performance

- Precise, granular, immediate monitoring metrics for trending, alarming, SLA reporting, and troubleshooting: all services, all layers, all sites and segments over multi-vendor networks.
- An open interface to Network State+ metrics provide a real-time feed to SDN controller, NMSs and other applications, making them performance-aware. This permits dynamic performance optimization that uses the current state of the network to determine the optimal network configuration at any instant.

On-demand, Dynamic Troubleshooting Tool Set

- Rapid isolation of faults with network segmentation, per-service and network layer visibility are augmented by adaptive monitoring that can selectively increase sampling frequency and metrics collected by site, service, customer or location. Monitoring resolution and focal points can be programmed by existing fault or network management systems, performance reporting platforms, and other third-party applications.
- On-demand or triggered Level 2-7 packet capture complements the most detailed network key performance indicators (KPIs) available for correlated, multi-layer troubleshooting and analysis.
- Real-time results reporting permits dynamic network optimization and rapid scenario-based troubleshooting with least-possible network impact and mean time to repair (MTTR).
- Patented in-service throughput testing enables updated services to be validated while the customer continues to use them (e.g. validate that bandwidth on demand is properly provisioned without requiring a service interruption). Integrating this capability with triggered text execution is an ideal complement to customer self-service portals where not only can additional bandwidth be requested, the result can be verified after automated provisioning completes.

Added Efficiencies:

- Wider QoS and QoE permits advanced, insightful remote troubleshooting, reducing truck rolls and extended on-site visits to diagnose problems.
- Real-time reporting and actionable alerts accelerates mean time to detect issues and respond, reducing MTTR and related SLA penalties and customer churn.
- Granular bandwidth reporting visibility, for both on and off-net services, ensures network capacity is best utilized and over-provisioning is minimized, saving cost in wholesale line leasing, as well as CapEx associated with network upgrades.

Cost-Benefits:

Dramatically Lower On-Premises Equipment Cost

- NFV-powered vCPE modules and fully-virtualized vmCPE realize 50-70% savings over standalone vCPE hardware. Advanced L2-3 traffic conditioning features also reduce routing and traffic management requirements.
- Compared with single-function devices (e.g. SFP capable of TWAMP reflection, but not traffic generation), Accedian's Modules support all key service assurance functions, from turn-up to monitoring and troubleshooting tools, allowing a single install to deliver value over the full service lifecycle.

Lower Head-End Equipment & Maintenance Costs

- With deployment options including installation on commercial off-the-shelf (COTS) servers or in fully virtualized environments, the SkyLIGHT platform does not require any specialized hardware to support control and orchestration functions, or to deploy service assurance VNFs. These options, combined with support for distributed NFV deployment models, ensure capabilities scale economically as platform use increases.

Usage and Requirement-Based Pricing

- Accedian Networks reduces upfront commitment and CapEx barriers to entry with a feature-based licensing model that allows a CSP to purchase only the features needed to deliver value in their particular operations model. As new capabilities are required, they can be added to the platform (and programmable endpoints) on a per-session/site basis to tailor solution needs directly to revenue-driving opportunities.

Capping Demand for Legacy Test Equipment

- Distributed testing eliminates the need for a fleet of handheld test sets, or adding centralized probe capacity, while interoperating with and supporting both test methods. This allows service providers to continue using existing assets without needing to further invest in these legacy solutions as services scale.

Maximizing Use of Existing Analytics Infrastructure

- Expensive analyzers, DPI platforms, and in-house tools can be more fully utilized with remote packet capture that brings data from all points in the network directly to these systems, maximizing their utility and utilization, and reducing the need to install new equipment to analyze traffic at specific network locations.

Simplified Sparing

- Programmable Modules do not require site-specific staging, so can be spared in lower numbers, and at a fraction of the cost of standalone vCPE appliances. Their small size permits low-cost, next day delivery to nearly any location in a standard shipping envelope. Hardened electronics and carrier-grade design ensure an MTBF multiples longer than the expected service lifetime.

Future-Proofed Upgradability

- NFV-based solutions, programmable Modules offer a non-disruptive, simplified platform for future feature addition, without barriers imposed by Moore's law or purpose-built hardware limitations. The SkyLIGHT Architecture is designed to grow with VNF adoption, QoE and analytics application innovation, and standards-based multi-vendor deployment models.

Service Differentiation:

Agile Services & Accelerated Time to Revenue

- Services can be deployed rapidly with customer self install and automated, triggered turn-up testing and service provisioning.
- Programmable performance assurance and provisioning functions can immediately adapt to updated service attributes, new managed services introduced, or new SLA reporting requirements. This allows customer-controlled services to be fully assured–and billed as premium, SLA-grade connectivity.

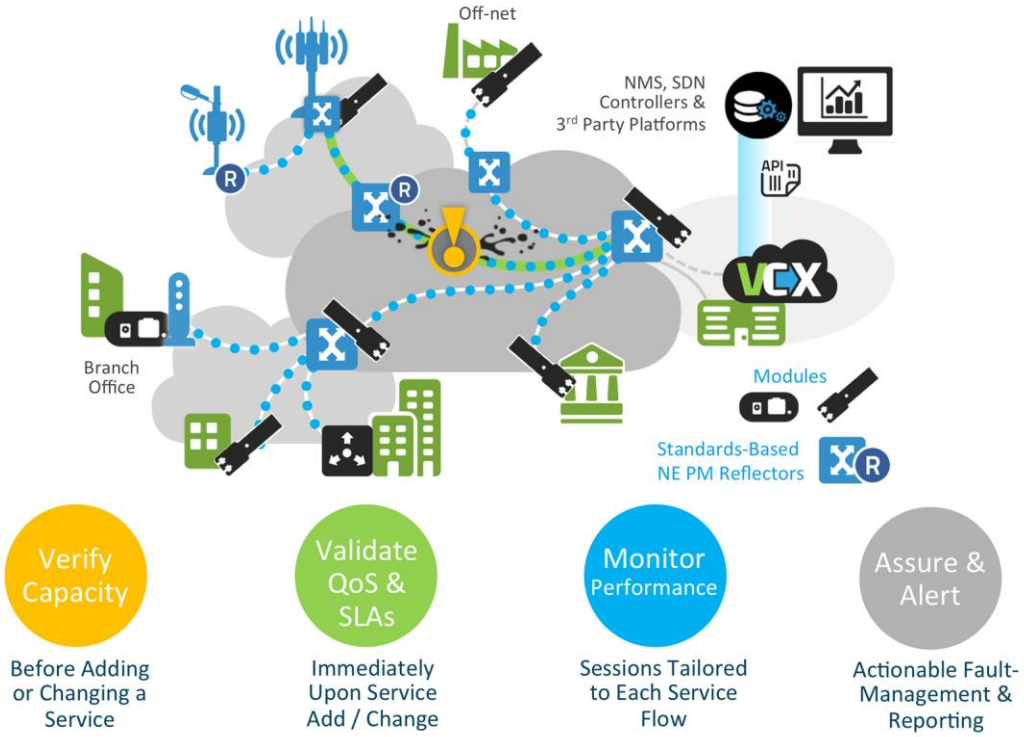
Performance as a Differentiator

- Full life cycle performance assurance increases overall QoS and QoE, providing competitive differentiation on performance instead of price.
- Integrated SLA reporting capabilities support multi-tiered, SLA-grade services with differentiated pricing and margins.
- A performance-assured product portfolio distinguishes CSPs from unassured public cloud and over-the-top (OTT) competitors.
- Future additions to the SkyLIGHT Performance Platform will permit granular application-layer assurance and Software-as-a-Service (SaaS) performance SLAs, amongst other methods that providers can employ to further differentiate their services.

NFV-Powered vCPE Applications

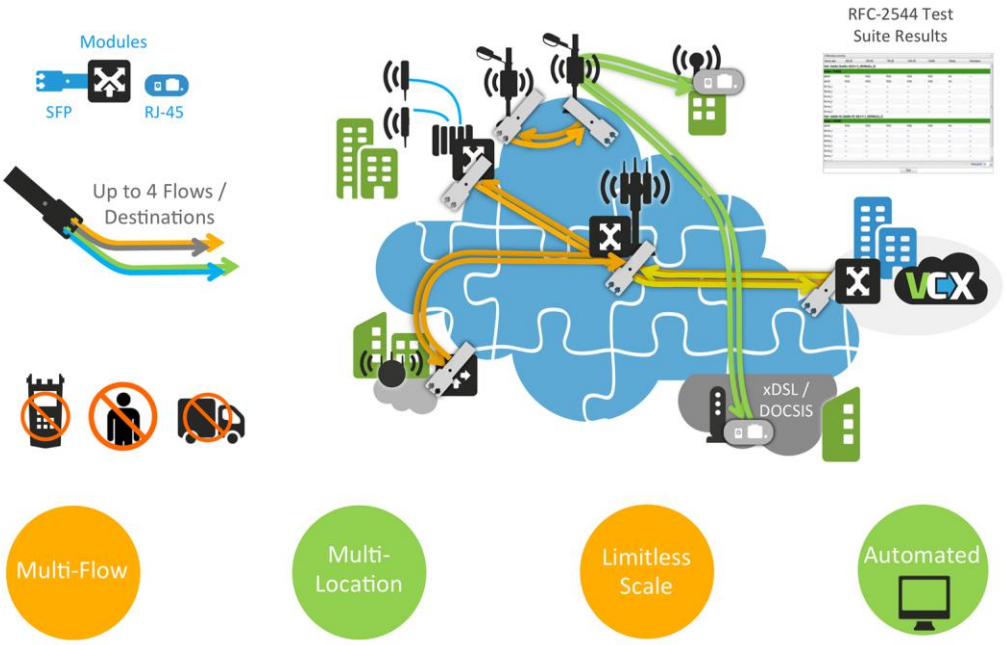
Without the cost and capability limitations of standalone vCPE appliances, NFV-powered virtualized instrumentation can deliver a wider range of performance assurance functions, including advanced applications such as distributed packet capture that are otherwise impractical or impossible to implement.

The full service lifecycle is covered:



The following sections provide a brief introduction to the main capabilities offered or planned for the Accedian SkyLIGHT Performance Platform, as well as the method NFV is employed in each application.

Service Activation Testing

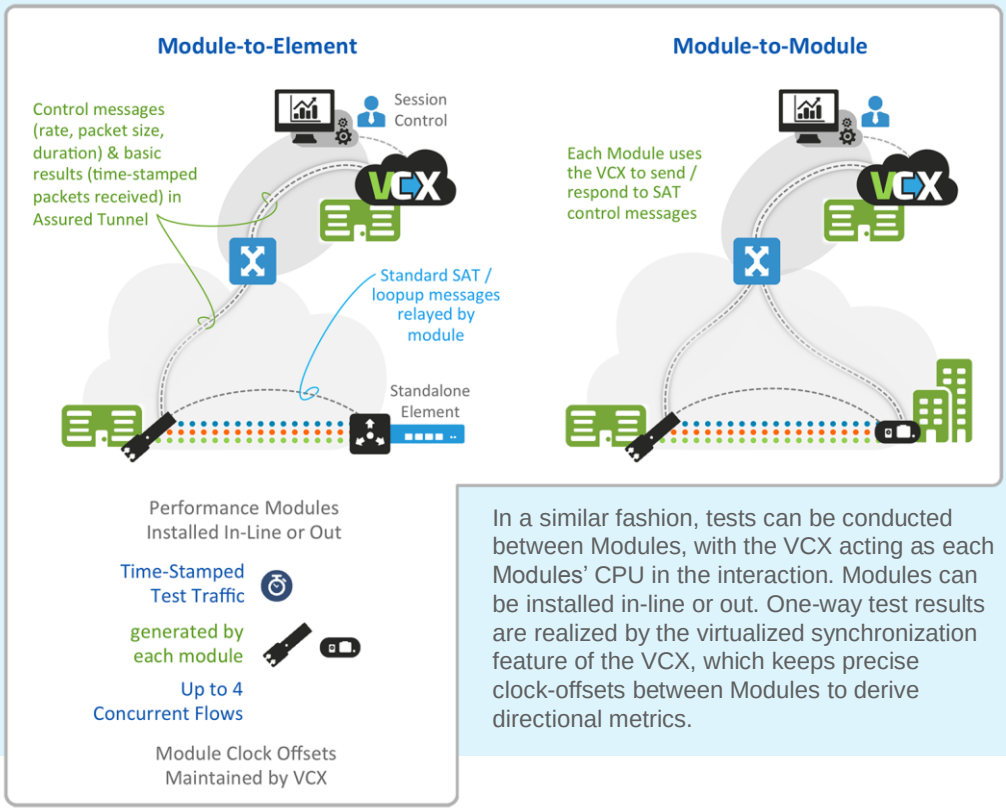


Unique to Accedian, Performance Modules are capable of full line-rate test traffic generation, able to create and analyze up to four unique flows, or run four concurrent RFC-2544 / Y.1731 service activation tests to multiple service endpoints. This allows service providers to test the actual service path at peak hours, without impacting the network more than the service itself would. Distributed traffic generation can be easily orchestrated and automated by the SkyLIGHT Controller, permitting flexible site-to-site testing, on demand or triggered service validation and troubleshooting. Truck-rolls and on-site use of labor and test sets is eliminated with Modules customers can self-install, retained for their complementary performance monitoring capabilities once the service is activated. Limitations of head-end, probe-based solutions are also eliminated: high cost, network traffic load, scheduling limitations, and the inability to test directly between sites.

SkyLIGHT VCX Implementation

The SkyLIGHT VCX Module and VNF Controller assumes all session setup, control, and sequencing functions, as well as results analysis and reporting. Modules respond to traffic generation commands (rate, number of packets, flow characteristics) to conduct tests, and pass base-level metrics back to the VCX for results processing.

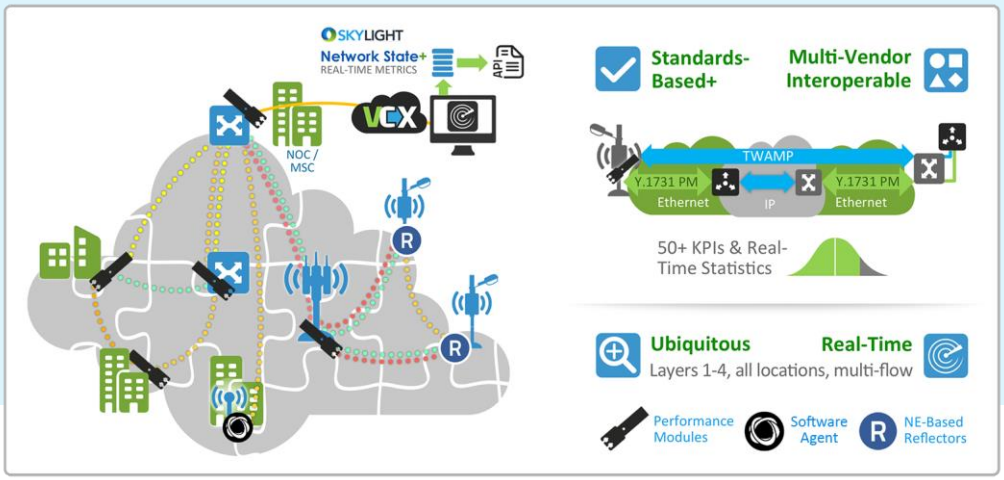
Two use cases are shown below, the first being a SAT test between a standalone Performance Element (vCPE) and a VCX-controlled Nano Module. Telemetry between the VCX and the Module transits through a secure, assured tunnel. To the Element, the Module appears to be a standalone, standards-based test endpoint. Any test protocol messages received by the Module are mediated by the VCX.



In a similar fashion, tests can be conducted between Modules, with the VCX acting as each Modules' CPU in the interaction. Modules can be installed in-line or out. One-way test results are realized by the virtualized synchronization feature of the VCX, which keeps precise clock-offsets between Modules to derive directional metrics.

Performance Monitoring

Standards-based TWAMP and Service OAM (SOAM) performance monitoring can be conducted in real-time over multi-vendor, multi-domain, and multi-layer networks using any combination of Accedian Elements, Modules, and multi-vendor networking hardware supporting standards-based reflectors. Thousands of sessions can be maintained by a VCX amongst its virtualized Modules. Real-time statistical derivatives of key metrics, including percentile and min/max/average values are calculated by the VCX in real time as results are processed, eliminating querying delays when using these higher-level KPIs in fault management and reporting applications.



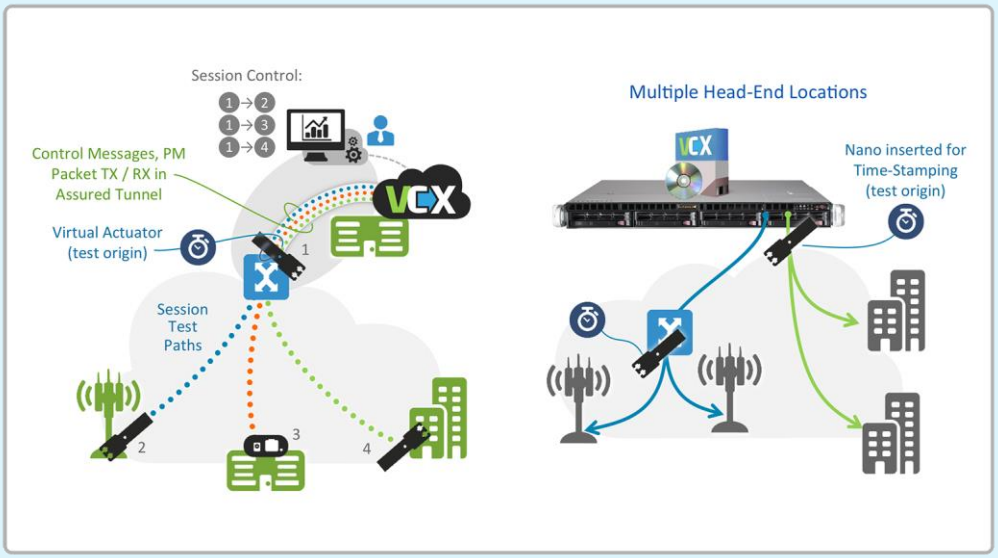
SkyLIGHT VCX Implementation

Performance monitoring (PM) sessions require session control, test packet generation, and precise time stamping at the test origin and endpoint.

The VCX assumes control over test session setup, inventory and results processing, as well as test packet generation using the PM VNF. Test packets are delivered to the Modules at the respective test origins, where they are time-stamped and relayed to the session endpoint. Upon receiving a PM packet, the Module stamps its time of arrival before sending related information to the VCX for result calculation. The VCX also separates out operator or domain-specific OAM results, for example differentiating Management Entity Groups (MEG levels) and providing the corresponding session details and alarms.

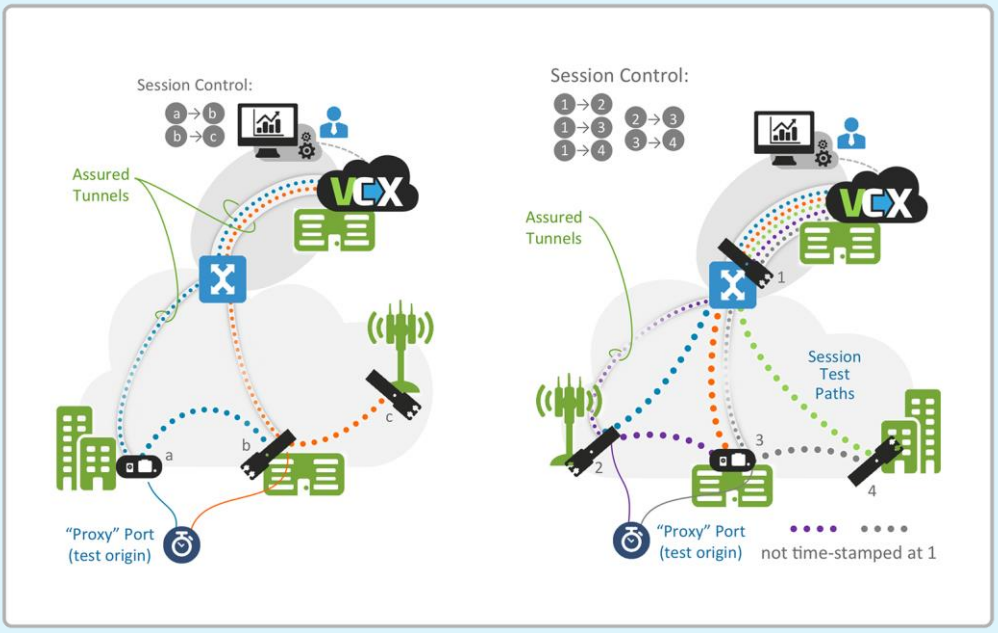
PM Topologies

The VCX can employ a Module as a virtual test actuator (probe), streaming thousands of sessions via a single unit, which time-stamps the test traffic at full wire-speed, whether installed in-line or out.



Centralized Testing With Virtual Actuator / Probe: diagrams only show one session between sites for the sake of clarity. Multiple head-end "probe" locations can be created by installing additional Modules where desired.

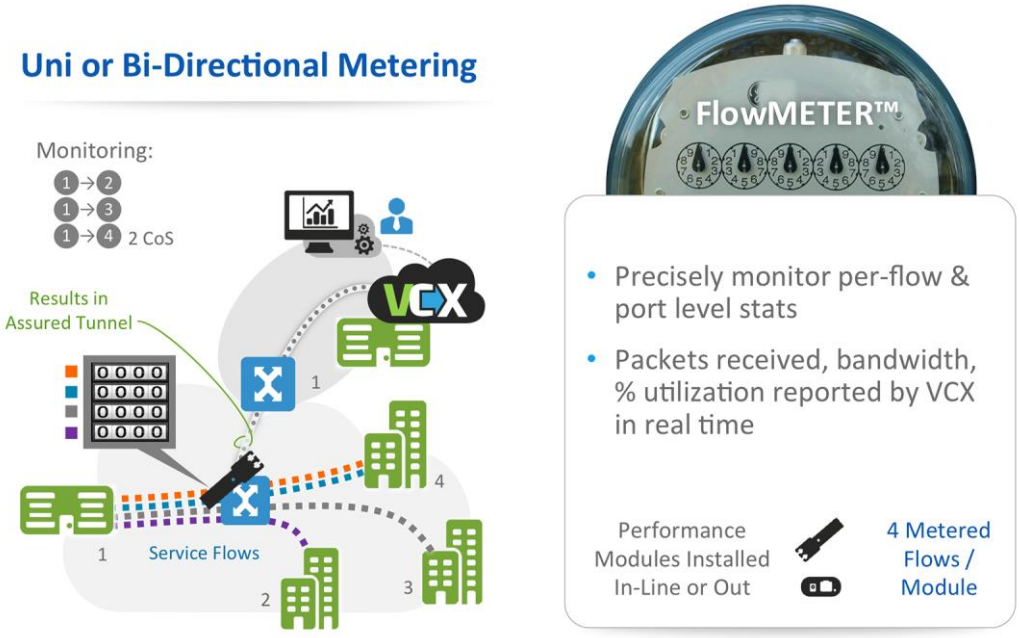
Tests can also be conducted between units, or in a full mesh fashion, providing the ability to test multiple services and QoS levels between sites without costly per-location equipment.



Site-to-Site & Full Mesh Testing: Remote PM Traffic Generation

Bandwidth Utilization

Bandwidth utilization, when precisely measured, can reveal transient micro-bursts leading to TCP throughput impairments. Per-service metering also permits usage-based billing, including on-demand and excess information rate (EIR) burst consumption pricing models.



Example of multi-service, multi-site utilization metering

SkyLIGHT VCX Implementation

The VCX processes per-flow bandwidth utilization metrics from Modules under its control, using time-stamps to accurately report throughput as well as consumption. When used in conjunction with packet loss and other measurements, service providers can detect network bottlenecks and estimate available capacity–key metrics to assure and enforce the delivery of off-net services. Upload and download usage statistics can be monitored separately, if desired.

The VCX can record granular utilization with per-second sampling.

Conclusions

The shift to federated and hybrid cloud from private data centers has shifted the role of business services towards assured data center connectivity. These services face intense cost pressure. However, quality of service cannot be sacrificed, since these services form the lifeline between enterprises and their business-critical infrastructure.

Cost savings and service agility are being realized by leading service providers virtualizing as many customer premise appliances and functions as possible, making the vCPE a critical component in a communications service provider's (CSP's) connectivity delivery model.

The logical extension of network function virtualization to applying this same approach to the vCPE itself minimizes the last remaining customer premises hardware required.

While NFV-based vCPEs drive out cost and offer substantial operational benefits, a comprehensive vCPE solution must be able to seamlessly integrate legacy and virtualized approaches into a seamless delivery platform to ensure a smooth migration from existing infrastructure and within existing operational practices. Accedian's SkyLIGHT Performance Platform provides an architecture that unifies physical and virtualized instrumentation, employing COTS hardware-based NFVI to efficiently provide scale up to address national-scale network footprints.

Beyond cost and operational benefits, NFV-based vCPEs offer the added ability to easily upgrade service assurance capabilities with new VNFs and applications as they are developed, setting a new standard for the capabilities vCPE will offer or broker. From DPI-based QoE monitoring to network security, TCP traffic and web service optimization, the extensibility offered by the combination of ubiquitous instrumentation and NFV-based innovation will help CSPs deliver differentiated services that position them as the connectivity partner of choice.