HEAVY READING REPORTS

Independent market research and competitive analysis of next-generation business and technology solutions for service providers and vendors

vCPE Test & Measurement: A Market Takes Shape

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1. EXECUTIVE SUMMARY

The metaphor for virtualization is the same one used to stand in for the Internet: a cloud. Whether it's the Internet specifically, or virtualized networks in general, the cloud remains an apt representation in that it's difficult to point to anything that is virtualized; it's more frequently a process than a thing.

That's a truism, but with virtual customer premises equipment (vCPE) there is, in fact, a very specific thing in a circumscribed place: a computer system or server sitting at a customer's location – a less-expensive, general-purpose replacement for special-purpose equipment. That is one of the biggest reasons why, nearly from the start of the virtualization trend, vCPE has been considered low-hanging fruit. During the earliest stages of virtualization, vCPE could be easily defined, making it easy to envision how to implement it. It was also relatively easy to envision a business case that benefits both service provider and customer – no small thing.

For service providers, virtualizing just about any part of the network has the potential to save both capital and operating expenses in several ways, but there's little opportunity to charge for, and gain revenue from, virtualizing network systems. Service providers can, however, charge for vCPE, as well as for expanded or new services based on it. Furthermore, with vCPE, a direct economic benefit for customers is clearly imaginable; a cheaper box is cheaper, and if it's also the vehicle for improved service, that increases the value proposition.

It was also easy to imagine that vCPE performance could be monitored and assured. Test and measurement (T&M) companies already had tools and techniques to evaluate the basic functionality of applications running in software on a device at the network edge; they have been doing that for the mobile phone market for years. Software agents and probes are in common use, and it was easy to conclude such techniques and tools could be adapted for vCPE.

Just as the market for vCPE is still developing, so too are the tools and techniques specific to vCPE that are necessary to determine that vCPE works as expected. Both specific-purpose CPE and general-purpose vCPE servers typically have a finite set of physical inputs and outputs to test before being installed and monitor once deployed. But where specific-purpose CPE typically has a finite set of operating conditions that can be exercised, often with standardized test routines, that is not necessarily true of vCPE. In instances where the user takes fullest advantage of the configurability afforded by virtualizing, the opposite is true. Under those conditions, the task of testing, monitoring and assuring vCPE can get complicated.

This report, part of Light Reading's Testapedia initiative, surveys the means and methods of monitoring and assuring the performance of vCPE. The market for tools to monitor vCPE is dependent on the challenges inherent in vCPE implementations, and the development of the market for vCPE itself, so this report also characterizes the vCPE market. It includes overviews of companies that provide the pertinent tools and services.

1.1 Key Findings

The vCPE market is still in its very earliest stages. The total worldwide market currently measures only in the hundreds of millions of dollars, but it is expected to grow rapidly because of vCPE's cost-saving potential.

The number of vendors competing in the vCPE test sector is likely to be limited. Spending on T&M tools typically amounts to a fraction of the market for what's being tested. The initial market for test, monitoring and assurance tools for vCPE will be small, measuring

in the tens of millions of dollars. That will naturally limit the number of competitors to perhaps a half dozen at most, and more likely fewer.

Creating effective software agents or probes to perform the necessary vCPE monitoring and assurance functions was a surmountable challenge, but it took time. The market's lack of confidence in available tools has been a damper on the vCPE market thus far. Suppliers of these tools are in the process of gaining that trust.

Virtualization does pose some new challenges for T&M vendors. A major challenge ahead for vendors of monitoring and assurance tools – and for the vCPE market in general – will be enabling their tools to be managed, especially in distributed environments in which the virtual network functions (VNFs) that are being monitored can be spun up or spun down, or scaled up and scaled down, in different places in the cloud.

The heterogeneous nature of virtualization will make vCPE testing an ongoing work in progress. The constituent elements of virtualized systems – orchestrators, microprocessors, different VNFs and more – come from different vendors, and all are upgraded on different schedules. It is simply impossible to test every single possible combination of products and product versions for incompatibilities. It is incumbent on vendors of monitoring and assurance products to meet this continual challenge.

More work needs to be done on testing at higher layers in the Open System Interconnection (OSI) stack. Test vendors are now providing testing, monitoring and assurance of virtual networks, including vCPE, at Layer 2 and Layer 3, but a challenge moving forward will be moving those capabilities up the OSI stack. Tools exist for monitoring and assurance at Layers 3-7, but there is work to be done to make the integration seamless.

The vendor lineup for vCPE test solutions remains fluid. As this report was being completed, Keysight Technologies announced its intention to purchase Ixia, one of the companies that provides tools for monitoring and assuring vCPE. If any other competitors plan to enter this market, buying one of the existing independent vendors, such as Spirent or Netrounds, may be the best option, rather than building a product line from scratch.

1.2 About Testapedia

Launched by Light Reading in 2016, Testapedia is a comprehensive online resource dedicated to the telecom T&M industry. In addition to offering the latest telecom T&M news and analysis from Light Reading, it offers free and open access to integrated, searchable databases covering all aspects of the telecom T&M sector, including companies and their products, key individuals involved in telecom T&M, industry organizations, partner ecosystems and a taxonomy of product and solution types. Registered users also have access to a research portal that offers free, downloadable research reports related to telecom T&M published by Heavy Reading.

1.3 Companies Profiled

Companies profiled in this report include:

- Accedian Networks Inc.
- CENX Inc.
- Ixia (Nasdaq: XXIA)
- Netrounds AB
- Spirent Communications plc (NYSE: SPM; London: SPT)

2. CHARACTERIZING THE vCPE MARKET

2.1 The Value Proposition

The potential of vCPE is clear. Special-purpose hardware can be replaced with less expensive commercial off-the-shelf (COTS) hardware, leading directly to cost savings. Functions are then implemented in software to make the general-purpose systems perform specialized tasks, leading to another fundamental benefit: service agility. Software can be reconfigured, scaled up or down, updated and replaced far more easily and cheaply than hardware.

The networking industry quickly identified CPE as the easiest special-purpose equipment to virtualize. Low-cost servers can be loaded with VNFs in containers, where they can be chained at application level with multiple other VNFs.

The proposition is compelling, which is why projections for the market are enthusiastic. IHS Markit in July 2016 valued the incipient vCPE market at less than $100 million in 2015, but it expects that to grow to $1.5 billion worldwide by 2020. The calculation includes what service providers spend on network functions virtualization (NFV) hardware and software to deliver software-based services to customers via both consumer vCPE and enterprise vCPE use cases.

This was IHS Markit's first estimate breaking out the vCPE market from the larger software-defined networking (SDN) market. The company assumes the vCPE market will grow at roughly the same pace it assumes the SDN market at large will grow, at a compound annual growth rate (CAGR) of about 42 percent.

The theoretical benefits are defined, the overall market is clearly growing and it's easy to assume that a subset of a market (vCPE) will track with the overall market. Theory began clashing with practice almost immediately, however.

2.2 Unexpected Consequences

With the first deployments, it became clear that merely replacing special-purpose CPE with a COTS system running VNFs wasn't the end of the cost calculus. Purpose-built CPE for the enterprise market that can be replaced by vCPE includes firewalls, network interface devices (NIDs), routers or Session Initiation Protocol (SIP) private branch exchange (PBX) systems, among others. Some of these products can cost $1,000 or more, depending on the system. Service providers looking to replace those systems typically desire a COTS device that costs somewhere in the $200-$300 range. COTS systems at $200-$300 are available; however, they are built on the least-expensive and, therefore, least-capable processors – typically single-core or dual-core models. Although a $200 server has limited performance, it can be adequate within a strict set of circumstances.

For starters, the customer must require a limited set of functions. When multiple VNFs are running simultaneously they can end up competing for resources. Under those circumstances, it may be difficult to guarantee performance of individual VNFs. The situation becomes more challenging when there is dynamic provisioning of VNFs for providing differentiated service based on the customer workload, one T&M vendor reports. Significantly, this becomes a limit on service agility.

This problem is exacerbated when software developers assume the virtualized versions of their products will have the same dedicated access to a processor core the original software

designed to run on dedicated hardware did. In a virtualized environment, such as vCPE, that won't necessarily be true – in fact, it's unlikely. This is an example of a special consideration that derives entirely from the virtualization process that vendors of test and assurance tools had to first identify and then account for.

Deploying the least-expensive COTS system also works better if traffic demands do not scale up or down much, either in terms of frequency of changes or in amount of traffic. The customers that fit that description tend to be small and medium-sized businesses (SMB) whose needs are modest and well-defined.

While it is possible that any given customer's needs might remain static, the likelihood is that the customer will grow or that its needs will change – it's the issue that the configurability inherent in vCPE is supposed to address. Additional customer requirements deriving from growth or expanded needs can lead to a dilemma for service providers, however.

Should a provider install the least-expensive vCPE implementation possible and the customer outgrows it, the service provider will then have to replace the original server with a more capable model, necessitating an expensive truck roll that virtualizing the CPE was supposed to have obviated in the first place.

One option for accommodating customer growth is to install a more capable model during the initial deployment, but that can be problematic for several reasons. A more capable COTS server will cost more, cutting into some of the savings that were the impetus for adopting the vCPE model in the first place. The price will increase with the number of processor cores. A COTS server with an 8-core microprocessor can be expensive enough to rival the cost of the CPE it's supposed to replace, fully negating the cost rationale for moving to vCPE.

The service provider could attempt to upsell the customer on enough additional VNFs to justify a more expensive server; several have tried this route. But customers don't always need or want to pay for the additional VNFs that would justify the hardware upgrade. Of course, service providers could opt to deploy more capable, more expensive servers even when customers' current needs do not justify doing so, leaving some of the compute resources lying fallow in a gamble that customers will grow into them.

The downside of those gambles is that if the customer never grows enough to make use of the extra capabilities, then the service provider has stranded its assets. It will never be possible for service providers to predict with certainty which customers will grow and which ones won't. Server companies are building systems with slots for expansion blades, which will address some of the difficulties presented with right-sizing, on-premises vCPE, but not all. Aside from everything else, there is no such thing as a cheap, carrier-grade COTS server.

Part of the reason that COTS servers can be used in a data center environment is that hundreds or thousands of them are there in a cluster. Should one server fail, the resiliency is in the numbers – workloads simply get shifted to another server. In a vCPE deployment, there's one server; if it fails, there are no backups. This doesn't make it any harder on test and assurance tools, but it does make it more critical to have such tools that are as well-developed as the state of the art allows.

So while vCPE as originally envisioned can be cost-effective in some instances, it does not guarantee decreasing costs or increasing service agility.

2.3 An Early Stumble

Little of this was anticipated, and it had a retarding effect on the early development of the market. At the beginning of 2016, Heavy Reading reported that early vCPE deployments have been disappointing. "It turns out, for a variety of reasons, that if a VNF vendor simply swaps a dedicated hardware environment for a virtual machine (VM) implementation of a network function, there are not many cost benefits after all," Heavy Reading found. "Thus, the business case envisaged more than three years ago has proved something of an illusion, at least when it comes to the cost-sensitive SMB, distributed branch office and consumer markets."

In the 2016 report, Heavy Reading concluded that "virtualization has highlighted these segments' reluctance to pay for large, monolithic pieces of network function when they don't need most of the features. So the race is on to find VNFs they *will* pay for and on which CSPs can make a profit – open source VNFs, for example, which also tend to package network functions more simply, a single feature at a time. With atomic VNFs, it's easier to give customers the choice to buy only the specific feature(s) they want."

The search for a more flexible and perhaps less expensive approach to vCPE has led right back into the cloud. Gaining in popularity are configurations that allow for shifting some or all of the VNFs functions into a hub or central office, which is to say into the cloud. There will still need to be some basic equipment on-premises to perform basic traffic handling tasks.

This approach gets around the problem of figuring out how to right-size the COTS box, while making it perhaps even easier to add and subtract different VNFs as needed, or to add or subtract iterations of a single VNF in order to scale a specific function up or down in response to demand. Workloads can reside in different data centers, and even be moved from data center to data center. Management of the vCPE can be accomplished from the network.

2.4 SD-WAN, Simultaneously

Once VNFs are drawn into the cloud, the vCPE approach begins to look somewhat like a software-defined wide area network (SD-WAN), depending on which of multiple definitions of SD-WAN is considered. The industry seems to be converging on the definition of SD-WAN provided by Gartner, which says SD-WAN has four key characteristics:

1. has a simple interface enabling remote management
2. supports multiple VNFs
3. can manage load sharing across WAN connections
4. supports multiple connection types, including Internet, Multiprotocol Label Switching (MPLS), Long Term Evolution (LTE) and others

SD-WAN emerged at about the same time vCPE did – in the last two to three years. They are both solutions a service provider can offer and a customer can buy. Both solutions provide similar benefits, both to service providers and to customers. Despite the two different names and two mostly different groups of vendors, there are many similarities (remote management, support for multiple VNFs, possibly load sharing). Some SDN vendors with SD-WAN products describe SD-WAN as residing on vCPE.

The confusion about the distinction between vCPE and SD-WAN extends to T&M companies, which do not agree whether SD-WAN is distinct from vCPE and competitive with it, or

whether the two can complement each other within a single network or (as one vendor suggested) SD-WAN is just a particular use case of vCPE – one that is well defined and, since it relies more on the cloud, avoids many of drawbacks of on-premises vCPE.

From the T&M perspective, many of the same tools can be used to test, assure and monitor them both. That said, it is interesting to note that analysts are sizing the SD-WAN market separately from the vCPE market, and they expect it to be significantly larger. IDC expects the SD-WAN market to be worth $6 billion by 2020; Markets and Markets projects it will be $9 billion by 2021.

2.5 Residential vCPE

At this point, vCPE is a phenomenon contained largely within the business and enterprise portion of the market. Service providers that offer broadband and video services primarily to residential customers are also interested in vCPE for all the same theoretical benefits – the ability to update or upgrade every individual unit of deployed CPE, at the same time, in the same way, with the same features, all without having to send a maintenance technician or installer to every single customer's home.

Cost concerns about vCPE in the residential market, however, are at least as acute as they are in the enterprise market – perhaps more so. The same cost concerns that had a dampening effect in the enterprise vCPE market have forestalled the residential vCPE market almost entirely. And yet, the potential benefits remain tantalizing.

Telefónica has been testing residential vCPE since 2014. It is partnered with NEC, as well as with NEC's Netcracker subsidiary, which specializes in SDN/NFV implementations. Telefónica is looking at a general-purpose home gateway, which most residential service providers expect will be more practical than some form of a set-top box. A gateway-type device is a more practical means of serving not just video and broadband services, but also home automation and other services.

Telefónica's Brazilian affiliate Vivo completed a field trial of vCPE in the summer of 2016. It has not publicly released any results. Telefónica's peers around the globe are hardly rushing to try to replicate its vCPE experiment. Orange Polska, the French operator's subsidiary in Poland, is one of the few that is; it has announced a vCPE trial based on the open source ECOMP SDN/NFV platform defined by AT&T.

While the growth in the vCPE market might accelerate greatly over the next three years, as IHS Markit predicts, the enterprise market will drive the vast majority of the growth in 2017.

3. TEST & ASSURANCE FOR VCPE

3.1 Where We Are Now

Although software-based testers, probes and agents are commonly used in networks, virtualized networks present new challenges when it comes to creating effective test agents. Some of those challenges have been met; others are ahead.

Some T&M vendors acknowledge that it took time to begin meeting the initial challenges for testing and assuring vCPE, which contributed to the relatively slow start of the vCPE market. It's a verity that companies are reluctant to sell or buy things if they're unequipped to discover what's wrong when those things don't work.

Testing a virtual CPE requires different techniques than a hardware CPE. In a service-chained environment, the workloads can flow in between the VNFs inside a hypervisor or between two hypervisor systems. To efficiently emulate and analyze this type of traffic flow pattern in the lab, the tester node also needs to be virtualized and sit inside the hypervisor along with the other VNFs.

The T&M industry is now providing tools for testing, monitoring and assuring performance, mostly at Layers 1 and 2, and is in the process of integrating those tools with others designed for testing at higher layers. Once a service provider can assure its customers that traffic is flowing, the next thing is to be sure that the service is behaving the way customers expect it to behave.

The issue with testing any virtual system is that not only must the network link be monitored, but the performance of every element of the NFV infrastructure (NFVI) ought to be evaluated to assure performance with every other network element.

NFVI can consist of servers, hypervisors, operating systems, orchestrators, VNFs, switches and network resources, all supplied by different vendors, with multiple vendors in each category, each providing products with individual quirks. Furthermore, every individual product is modified, upgraded and changed on a different schedule.

Determining that all versions of every product work as they should with every version of every other product it might have to interface with is an arduous task. It is simply impossible to keep up with all the new product introductions, all the new upgrades and all the new versions, no matter how automated the test process is.

One of the few practical responses is for service providers to standardize on tested configurations that include specific revs of the various NFVI elements. While that might be good from a service assurance standpoint, it severely minimizes the freedom to quickly deploy any attractive rev as it is introduced, which in turn diminishes service agility. By restricting itself to a set of tested NFVI configurations, a service provider may not be able to respond immediately to competitors as they introduce new services or features.

3.2 What's Coming

Testing, monitoring and assuring vCPE is difficult enough when vCPE resides largely in a COTS box on customer premises, but it is exacerbated when the vCPE implementation is drawn into the cloud. How does a service provider even know when or where to deploy a

test agent? In this circumstance, it appears that the test agents will need to become subject to orchestration, just like any other VNF.

Accedian, for example, is developing a response it calls chaining segmentation. If a workload moves, say from one data center to another, the company is looking at how to rely on orchestration to make sure the test agent moves with the workload so that the service provider can isolate the location of any service difficulty.

Enterprises will want to monitor the traffic flowing in and out of their branch network, as well as between the network functions. Hardware taps cannot provide visibility into the hypervisor traffic without impacting performance; the response is to devise a virtual tapping solution. Ixia's Phantom vTap is one such example.

A separate issue is that carrier grade CPE frequently has test functions built in; traffic generators and reflection capabilities are two examples. When a service is spun up, that allows the service provider to stress test it immediately. These capabilities are almost always lacking in COTS systems used as vCPE. Some vendors believe it would be useful to build test capabilities directly into vCPE. Doing so would certainly increase costs, but some service providers may consider it worth it to gain a greater level of service assurance.

4. COMPANY PROFILES

4.1 Accedian

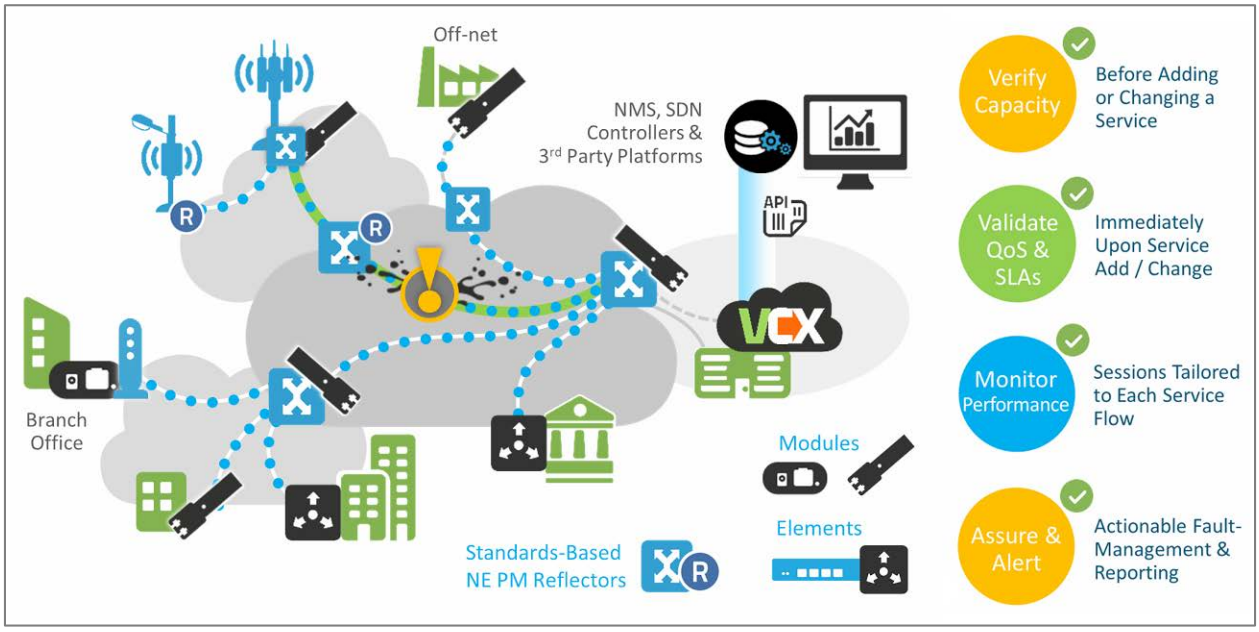
Accedian sees its position as performance monitoring from data center to data center; its main concern is WAN. But as vCPE and SD-WAN solutions overlap, Accedian ends up addressing some of the problems common to both.

One such concern is what happens if a workload moves, say from one data center to another. The company is experimenting with orchestration techniques to make sure that test agents moves with the workload. If successful, service providers will be able to isolate the source or location of service impairments. Accedian is calling this service chaining segmentation.

Accedian calls its platform SkyLight. It describes SkyLight as a fully-virtualized performance assurance platform, delivering network-wide visibility to service providers and enterprises. The company explains the platform uses the network itself as part of its virtualized instrumentation architecture. The SkyLight system uses big data analytics, reporting and control systems – essential to achieving peak performance in complex, large-scale networks.

SkyLight extends beyond monitoring to directly deliver, enforce and optimize quality of service from end-to-end – a solution that assures many of the world's largest mobile, enterprise and carrier networks.

Figure 1: A Uniform Instrumentation Layer for Multi-Vendor, Multi-Technology Networks



Source: Accedian

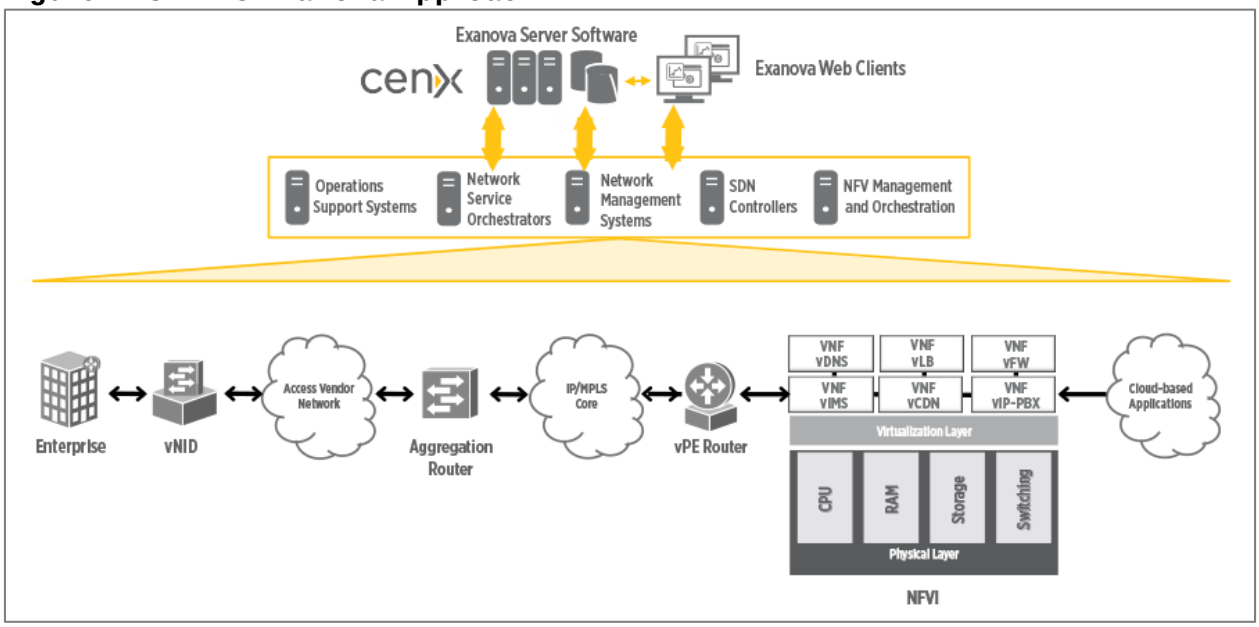
4.2 CENX

CENX specializes in data analytics that network operations centers (NOCs) can use to bolster service assurance. The company's Exanova product is a platform for aggregating network

data, including data from agents and probes. It can then analyze data from multiple sources in the network, making correlations that indicate the service impairments, enabling the NOC to respond more quickly to rectify problems.

CENX positions its system as a means to deal with the complexity of managing a multi-vendor systems in which physical and virtual infrastructure is operated side by side. As vCPE and SD-WAN solutions overlap, CENX ends up addressing some of the service assurance problems common to both.

Figure 2: CENX's Exanova Approach



Source: CENX

4.3 Ixia

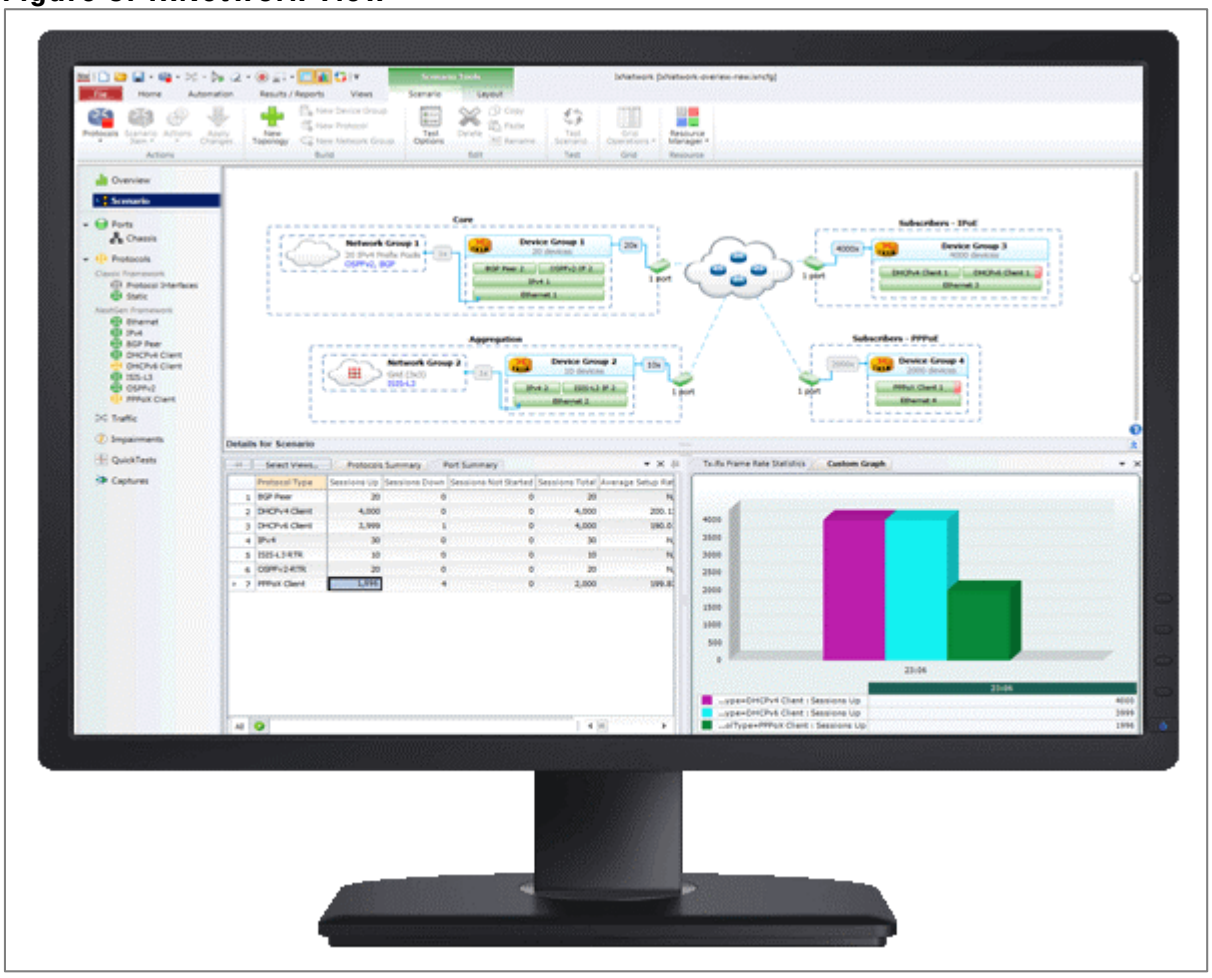
Ixia has made all vCPE testing capabilities available in virtualized form through a set of products, including its IxNetwork VE, IxLoad VE and BreakPoint VE.

IxNetwork is the company's network infrastructure performance testing solution; the Virtual Edition (VE) was optimized specifically for virtualized networks. The product uses scaled protocol emulation to test network infrastructure, capacity, scalability and convergence to ensure performance of data center and cloud computing environments.

The approach includes the ability to benchmark performance of virtualized servers by simulating data center traffic between virtual machines; Ixia claims this capability is unique to IxNetwork VE.

IxLoad VE supports functional and performance testing of virtualized servers and 10G Ethernet converged network adapters (CNAs) for cloud computing environments. The company says it is able to test a range of virtualized assets, including firewalls, deep packet inspection (DPI) devices, load balancers and other network devices. Ixia BreakingPoint (VE) is the company's tool for security testing.

Figure 3: IxNetwork View



Source: Ixia

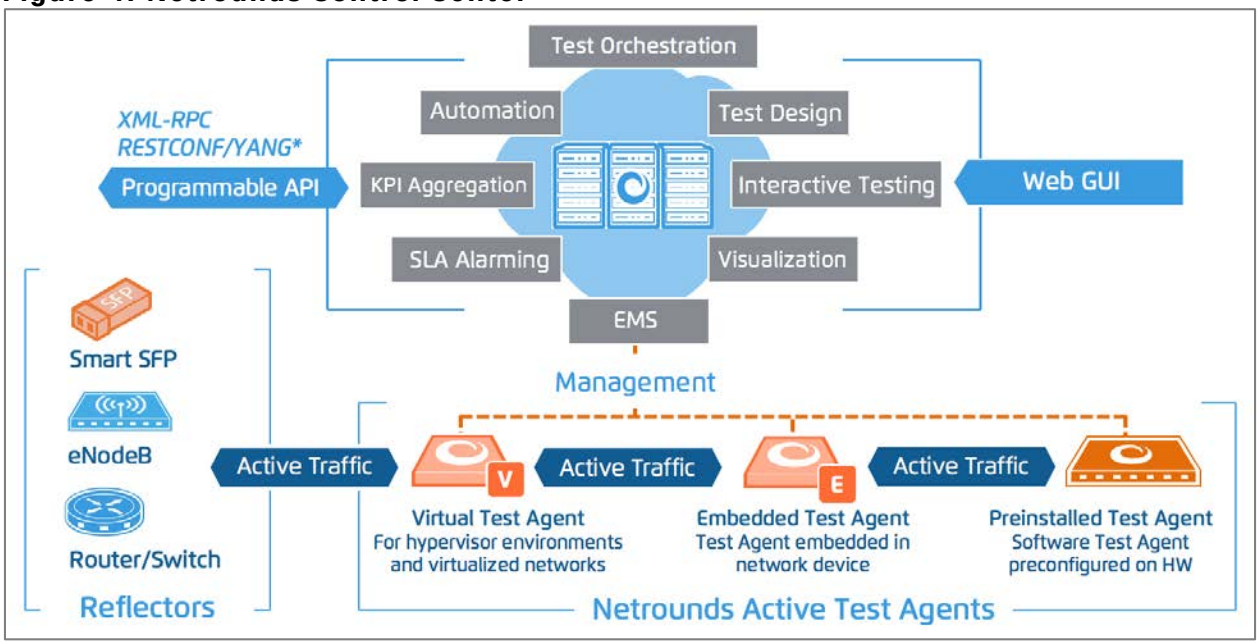
4.4 Netrounds

Netrounds aims to be able to provide end-to-end testing, monitoring and assurance in production environments, using software-based test agents that can be invoked by an orchestrator. The core component of Netrounds is a unifying multi-tenant Control Center that provides a consolidated graphical user interface (GUI) for operations staff, as well as a cloud applications programming interface (API) for external operations support system (OSS) and NFV orchestrators to remotely control and monitor Netrounds' active, traffic-generating Test Agents.

These software-based Test Agents provide distributed, end-to-end service insights across service activation testing, quality monitoring and troubleshooting. These insights can either be retrieved by Orchestrators/OSS for full closed-loop automation or viewed in the Control Center for the diagnosis and resolution of end-to-end customer service and network quality issues.

The Control Center is either hosted by Netrounds and offered as a software-as-a-solution (SaaS) solution or deployed on-premises.

Figure 4: Netrounds Control Center



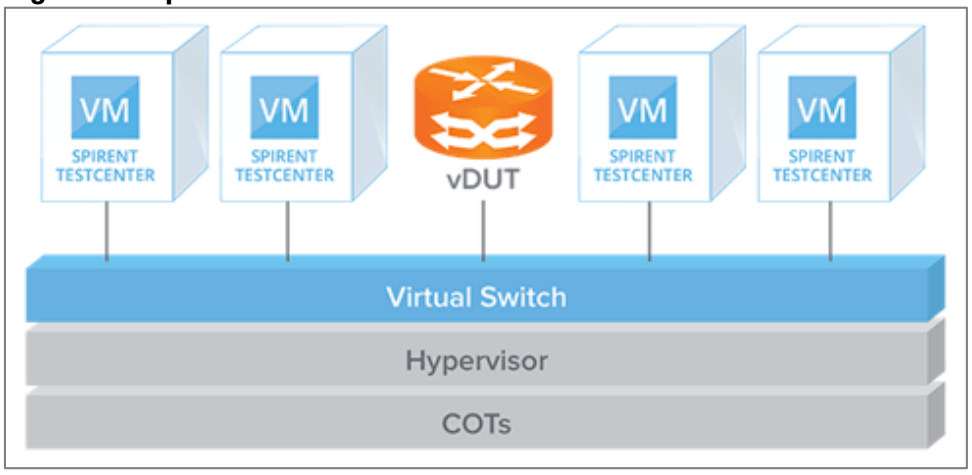
Source: Netrounds

4.5 Spirent

Spirent positions itself as a supplier of end-to-end validation, from the development stage to reliability testing to service assurance. Spirent's Virtual solution delivers a unified testing architecture that ensures compatibility with any Spirent TestCenter interface and enables porting of prior investment in test cases for physical to virtual.

Spirent's T&M solutions encompass a range of SDN and NFV operational T&M requirements, including cloud stack layers, NFV elements, IP infrastructures, mobile virtual core and edge elements, application and security assurance, service assurance and orchestration and test automation requirements.

Figure 5: Spirent's Virtual Solution



Source: Spirent

5. CONCLUSION

The market for vCPE has been slow to take off, in part because the inherent benefits can be undermined without a well-planned implementation and in part because the technology – including monitoring and assurance tools – wasn't ready. But now it is now poised to accelerate. Many of the unforeseen pitfalls have been identified, and effective tools are available for monitoring virtualized systems and configurations, with tools to assure network performance on their way. The market should also get a boost from service providers' resolve to deploy implementations that shift more resources off the premises and into the cloud.

T&M companies still have work yet to do. While they can evaluate whether a network with virtual elements is performing as desired, they will need to take their capabilities to the next level and be able to assure quality of service and quality of experience.

The vCPE monitoring and assurance market will grow only large enough to sustain three or four (at most) vendors. Testing, assuring and monitoring virtual networks are profoundly complex, highly esoteric endeavors; this will keep the number of vendors in this field low – perhaps six or eight at most.

That also means that independent companies with these specialties are likely to become acquisition targets for larger companies looking to secure a piece of the network virtualization pie, just as Ixia caught the attention of Keysight. The pool of possible acquirers is likely to include not only classic T&M companies similar to Keysight, but also OSS/BSS companies whose remit has been bleeding over into service assurance for some years now.

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