White Paper

vCPE: Virtually Accommodating the A-List Drivers

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Introduction

For years, the enterprise and residential services markets have been dominated by a dated and closed physical architecture and service delivery model that has stifled service innovation and maintained a high cost structure.

As a result, when network functions virtualization (NFV) emerged more than two years ago, addressing these shortcomings became a high priority via virtualized customer premises equipment (vCPE) initiatives, since leveraging open compute platforms and distributed software either in the cloud or at the customer premises can in a single step transform the landscape.

Accordingly, vCPE is now moving into the commercialization phase, with strong demand and commitment to implement from network operators such as AT&T, Telefónica, Colt, CenturyLink, BT, Verizon Business and Integra, among many others.

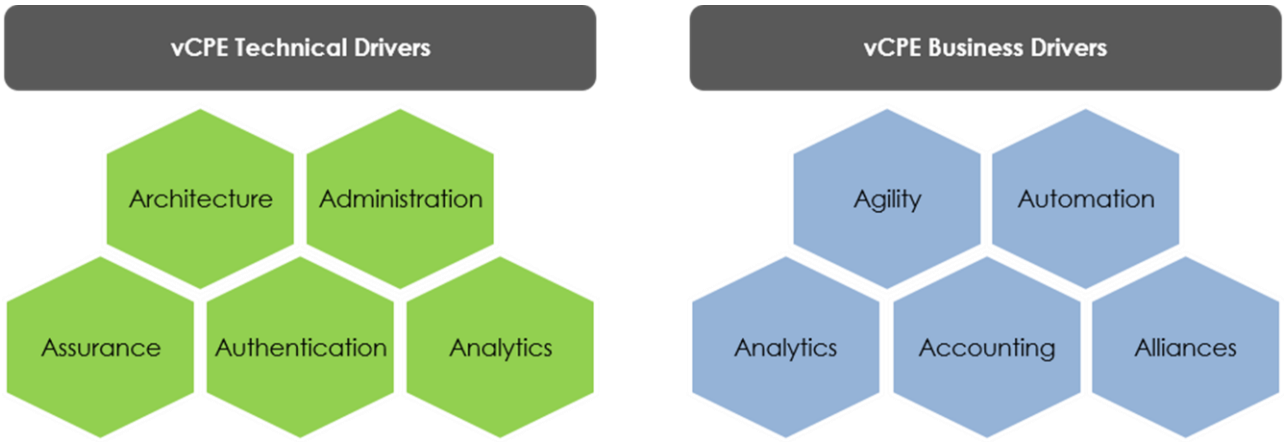
Therefore, the focus of this white paper is to document in detail the benefits and monetization opportunities that vCPE empowers. A profile of innovative network operator Integra is also included to provide a carrier-centric view of what is driving its vCPE commercialization strategic initiatives.

vCPE: The A-List Technical & Business Drivers

As touched upon in the introduction, vCPE has garnered significant interest from both network operators and enterprise providers – and for good reason, since its impact on the enterprise is profound on many levels. vCPE has a positive impact on a broad range of technical and business drivers that the current legacy CPE model can simply no longer even conceptually accommodate.

As shown in **Figure 1**, these areas of influence, which we refer to as the A-list drivers, address such vital considerations as architecture, agility, automation, authentication and even accounting.

Figure 1: vCPE: The A-List Technical & Business Drivers



Source: Heavy Reading

Technical Drivers

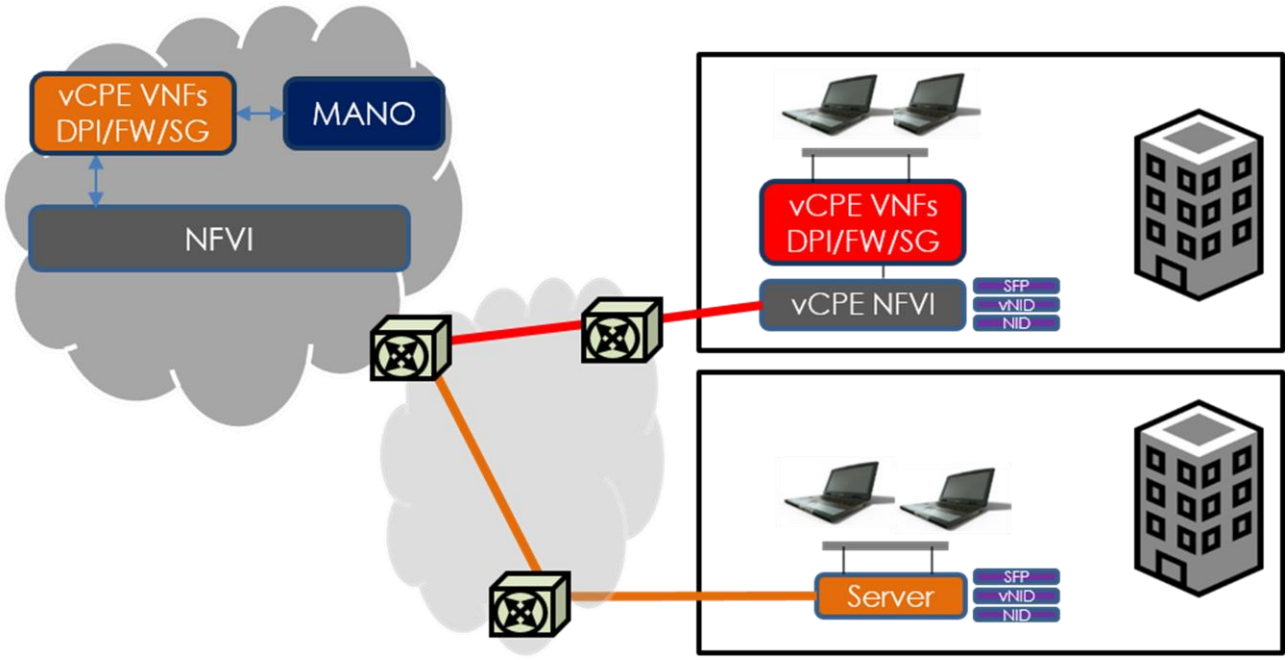
Architecture

One of the key technical advantages of adopting a vCPE architecture is that it represents a powerful and flexible approach for undoing all the limitations of the legacy embedded proprietary model. This is because vCPE supports a number of architecture approaches based on customer requirements, and since it is software-centric, it is extremely flexible and adaptive.

For example, we show several options in **Figure 2**. In the first, the enterprise has implemented a "white box" x86-based server, which supports essentially only basic Layer 2 network interfaces, while the actual associated vCPE virtualized network functions (VNFs) are hosted and orchestrated in the centralized cloud on NFV infrastructure (NFVI). This represents a lower-cost approach for an enterprise or network operator that has deployed a fully functional centralized cloud to host vCPE and other NVFs.

In the second approach, the enterprise has made the decision to implement NFVI compute and storage platforms as well as the vCPE at the customer premises. This delivers a greater degree of intelligence at the customer premises and is well suited for the delivery of enterprise services, where more complex services are delivered and a greater degree of end-user control is required.

Figure 2: vCPE: Architecture Configurations



Source: Heavy Reading

While these approaches are considerably different, it is important to note that both are valid and driven by the extent to which the network operator and its enterprise customers wish to support CPE functions on the vCPE premises or the centralized hosted cloud to support a more unified control and orchestration model. Both approaches are often supported by lightweight, low-cost programmable network interface devices (NIDs) or NFV-based, programmable hardware modules such as smart small form-factor pluggable (SFP) devices. This minimum hardware can provide a range of benefits that only line-rate, full wire-speed processing can provide, that would otherwise be lacking in pure x86 hardware. These capabilities include:

- Precise per-flow performance monitoring of latency, jitter, loss and other key service-level agreement (SLA) metrics (to sub-microsecond resolution).
- Ethernet service OAM over multiple classes of service, to assure QoS of flows destined for multiple endpoints, or to assure individual applications (e.g., SaaS, video conference, etc.).
- Active test for remote turn-up, service activation and performance validation on demand, or as triggered by customer self-service portals.
- Lossless remote packet capture and brokering, for security, policy enforcement, traffic analysis and analytics without requiring local analyzers at the PE.
- H-QoS traffic priority enforcement, to optimize access line efficiency, and assure transport of SLA-critical applications.
- Offloading traffic filtering, access, encryption and mapping functions from x86 NFVI, to ensure that VNFs offer the best possible performance on economical hardware.

- Categorizing traffic flows for efficient processing by core-optimized compute schemes (e.g., receive-side scaling) that allocate particular flows to designated CPU cores to optimize VNF performance for latency-sensitive functions.

It's also important to consider that a hybrid approach of both options can be implemented based on specific customer requirements in which some functions are virtualized in the cloud and others on the customer premises using either a traditional or virtualized NID (vNID). Since these small units are zero-touch in terms of provisioning, they can be installed directly by the end user.

As a result, vCPE's architecture options deliver a highly flexible approach that meets individual enterprise operator requirements. As a proof point, as documented in Heavy Reading's recent 2015 Carrier Ethernet Survey, when asked about which architecture they would implement, there were three almost equal responses:

- Traditional NID in conjunction with CPE NFV functions hosted in your data centers (43%)
- NFV-based NID in combination with on-site commercial off-the-shelf (COTS) servers for CPE function virtualization (41%)
- NFV-based NID in combination with CPE NFV functional hosted in your data centers (41%)

Administration

Another key reason to adopt vCPE is that it greatly simplifies the network administration model. It's no secret that network administration of the legacy CPE model has become a patchwork quilt of proprietary vendor monitoring tools designed to support their own products. In contrast, because it represents a distributed rather than embedded software model, the vCPE model is delivering on the promise to support administration of both vendor and third-party developed vCPE VNFs wherever they reside, which greatly simplifies network administration.

In order to accomplish this, one change that will be needed is to introduce a more flexible Web portal approach, where network operators can capture performance data and monitor the health of individual vCPE VNFs wherever they reside in the network in order to map them to specific enterprise customer SLAs.

Assurance & Analytics

The concept of service assurance in the context of managing QoS for enterprise applications is changing. Whereas in the past, the legacy enterprise could manage basic QoS metrics, since it was tightly engineered and overprovisioned, this model can no longer be supported. There are several reason for this.

First, the impact of bring your own device (BYOD) policies in the enterprise requires service assurance capabilities that are much more intelligent and flexible to enable device flexibility, rather than a hard-coded system of programming support for only enterprise-approved devices. Additionally, legacy enterprise networks' service assurance requirements are further shaped by the implementation of both SDN and NFV.

Specifically, a key factor that must be considered here is that enterprise networks will for some time run in a hybrid configuration in which some applications will be cloud-based and subject to dynamic service assurance requirements, while others remain on legacy platforms support more static service assurance requirements.

Moreover, to accommodate this hybrid model, service assurance must be extended so that it can manage and integrate data from a number of network sources (e.g., cloud, edge and enterprise) instead of from a single enterprise network source. Solution architectures that combine centralized or highly virtualized appliances with distributed data collection instrumentation or VNFs allow a unified view of the network state to be efficiently aggregated to interface with other network management and reporting platforms, including big data analytics systems.

Support of this hybrid configuration demands that service assurance be extended to support more real-time and flexible tools to manage and predict service assurance levels. Therefore, service assurance in the enterprise has become far more linked with the deployment of analytics. Full network- through application-layer visibility is becoming critical, as enterprise customers generally base their assessment of the QoS of their connections through their users' view of application performance.

In essence, this is because the shift to a dynamic and hybrid service assurance model can only be accommodated with the ability to analyze network data such as jitter and delay in real time from various sources. This is driving performance assurance platforms to report in real time, and to also be responsive: programmable to adapt to changing service-level specifications that can be easily changed directly through customer portals.

Another factor is that speeds and capabilities continue to rise from 10 Gbit/s to 100 Gbit/s, which means more data and more bandwidth applications and sessions that must be managed from a service assurance perspective. This had less impact in the legacy enterprise, since often the enterprise supported only low-speed, low-capacity interfaces, which did not drive highly volatile traffic patterns. Active test methods that decouple monitoring visibility from port speed, including approaches that use VNFs to conduct critical measurements, address this requirement in a cost-efficient manner.

Authentication

Similar to service assurance, admission control and user authentication must be totally revamped to support vCPE and cloud access in a real-time context. This represents a considerable challenge in the legacy enterprise, since security feature software is traditionally embedded in standalone applications. The increasing number of mobile users that are leveraging IP connectivity for mission-critical applications is making securing the vCPE enterprise even more challenging. As a result, new more powerful software approaches are now needed.

Overall, vCPE is well suited to meeting these security challenges because it can support a number of powerful real-time capabilities, such as packet stamping and DPI, to enable the network to validate and authenticate users as well as applying intrusion detection policies, wherever the users are physically located. In this scenario, analytics also plays a key role in identifying potential out-of-trend end-user application or usage patterns that point to a malicious third-party intrusion.

Another factor that we believe is in play from an authentication perspective is the evolution of the enterprise service user model. By this, we mean the notion of a temporary enterprise becomes a valid use case for driving new carrier enterprise revenue. In this use case, since vCPE can be deployed on the customer premises or in the cloud, there is no longer a physical boundary for where enterprise services can be provided. Perhaps even more importantly, they can be delivered on a temporary basis, which is not possible today due to both time and cost constraints. In this new model, vCPE VNFs can be used to spin up new enterprise networks, a major breakthrough in how enterprise services are delivered (see **Section III**).

Business Drivers

Agility

vCPE adoption is also shaped by A-list business drivers. At the top of that list is application agility in a business context. When you think about it, the only way to effectively replace a stagnant and entrenched business model for enterprise services, is to move to a software-enabled vCPE agile model. This is vital, since it opens up a model in which applications can be delivered anywhere, but also in much shorter timeframes. In many respects, the hallmark of legacy enterprise services is that they scored very low on the agility scale. This is due to a number of factors, including costs and proprietary-driven integration difficulties, which resulted in long lead cycles to bring them to market.

Another business reality is that once the decision was made to deploy a particular enterprise service, it remained in the network and consumed resources even as user metrics declined, effectively placing the application in storage mode. Consequently, enterprises require an agile model that can be bring new applications to market expeditiously, coupled with a business model in which network resources are tied to application lifecycle (and VNFs) to optimize revenue. Since vCPE is demand-driven and extremely agile, it also represents a truly unique opportunity to drive new enterprise applications that does not currently exist.

Automation

One agility enabler is automation, or the ability to implement software-based vCPE services with little or no provisioning touch. The end result is that network services and virtualized functions such as firewalls, DPI nodes and security gateways can be delivered in much shorter time frames and at a much lower cost, since the opex associated with truck rolls and site visits is eliminated.

A key enabler here is the deployment of a customer portal that enables the end user to control and pseudo-provision control of some applications. This not only enables a no-touch approach, but also enhances the perceived user experience by providing a real-time reporting interface to view SLA and per-site, per-application performance, ensuring that the end user directly sees the benefits of the provider's network, where performance is the operator's key differentiator over OTT services and basic Internet connectivity.

Additional efficiencies of the use of these network functions can also be achieved if SDN service chaining is supported, which enables the insertion of specific functions in path when required to support specific applications.

In contrast, the current legacy enterprise model is opex-heavy, as it normally requires a site visit and is very time-consuming, since it is hardware- rather than software-centric. In addition, by default, all network-specific functions are statically consumed for all applications, since the concept of service chaining is not supported.

Analytics

We have also included analytics as an A-list business driver, since it not only plays a strong role on the network side, it also delivers a strong value proposition in helping network operators to enhance user experience, create targeted marketing campaigns via data marts and even make strategic decisions on which parts of the network may require additional investments to ensure that sufficient capacity is available for high-value customers' usage patterns.

Without real-time subscriber data, it's extremely difficult to understand in detail the application consumption nuances that could have major impacts on the ability to retain or generate future revenue. The legacy enterprise CPE model does not support this real-time analytics usage model; instead, it was designed to provision enough hardware resources to support the number of anticipated users. As a result, it's difficult for network operators to upsell enterprise applications such as unified communications (UC), since they lack valuable insight into which applications would be perceived as valuable by which specific user groups.

Accounting

Within the realm of accounting, there are a number of key considerations. First, as noted in the interview we conducted with Integra to assess the impact of specific A-list drivers, progressive network operators are looking to shift their enterprise vendor payment models. Specifically, Integra is looking to leverage the vCPE model to move from an entrenched network capex model to a model where it purchases only the software VNFs required to match demand, instead of overpaying for capacity to meet busy-hour/busy-day traffic thresholds.

This same methodology can be applied in a customer-facing approach. As we have documented, vCPE can support more innovative, flexible high-value models in which the end user pays based on a consumption model that is enhanced via specific, targeted application upsell-driven campaign initiatives. Since application consumption is tied to vCPE VNF resources, a lower-cost, value-driven charging model can be offered to end users. Moreover, when supported via a customer portal configuration noted above, a number of flexible options can he chosen and modified by the end user based on specific event or application preferences. This completes the customer experience circle, since the end user has the ability to not only control access to applications, but also be changed for these applications based on their preferences.

Alliances

The final business driver is the undisputed requirement to drive innovation in the cloud and at the customer premises through an increased focus on third-party ecosystem alliances and partnerships. The enterprise is no different, and we believe it has long suffered from the lack of third-party application integration due to the highly proprietary nature of the legacy enterprise. As a result, we see considerable pent-up demand to usher in a new era of service innovation in the enterprise.

Since third-party development can be delivered via software-only VNFs, integration of these VNFs is a much less complex exercise than the current model, where third-party applications are delivered on specific hardware platforms, greatly increasing the cost and timeframe to integrate. Another consideration we have already discussed is that because vCPE VNFs can run either in the cloud or at the customer premises, the network operator can select the integration approach that best meets its business and application hosting strategies.

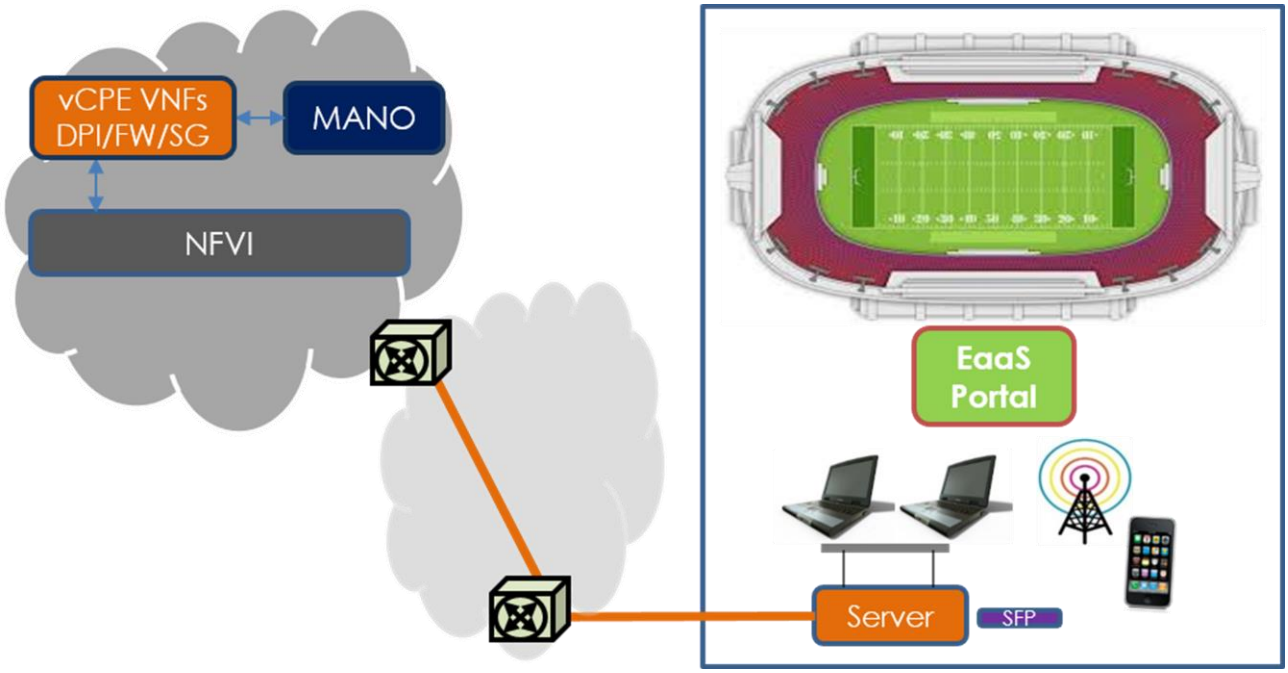
Another area of collaboration is between service providers themselves, as enterprise customers see great value in working with a single provider that offers access to its full roster of enterprise locations, private and public clouds, partners and more. Seamless end-to-end connectivity often requires partnering with other carriers, and these relationships – both long-haul transport, and notably last-mile access – are becoming critical to providers competing for the connectivity business of multinationals.

vCPE Use Case

In this section of the white paper we present a single vCPE use case to reinforce the value proposition of vCPE relative to the A-list technical and business drivers. The use case presented is what we refer to as Enterprise as a Service (EaaS), which enables a network operator to deliver enterprise services on a temporary basis for high-value existing or new enterprise users.

The scenario we document in **Figure 3** is that of a fully functional enterprise network deployed in a very short timeframe to support a week-long major sporting event. Today in the legacy enterprise world, this high-value scenario is extremely problematic, because it's cost-prohibitive for both network operators and end users. However, in today's world in which sporting events are heavily intertwined with social media applications, they are also much more media events that network operators should be exploiting to drive new enterprise revenue streams.

Figure 3: Enterprise as a Service (EaaS)



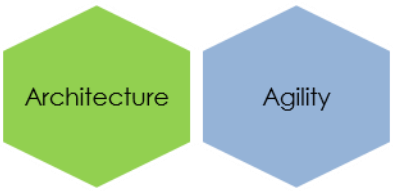
Source: Heavy Reading

Use Case Steps & A-List Building Blocks

Step 1

The network operator sells EaaS to a new international enterprise customers to cover a specific sporting event. The network operator deploys an x86 on-site and hosts the required VNFs in the cloud. In addition, a programmable smart SFP device can be added at the service endpoint to provide NFV-based turn-up testing to validate circuit installation and network-level SLAs, and provide real-time monitoring of the links over the course of the event, should assured performance be critical.

Building Blocks:



Step 2

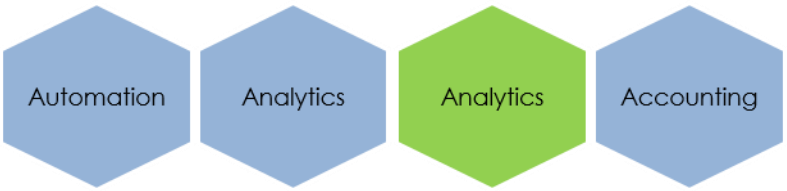
The network operator deploys an EaaS portal to enable new users to gain access to initially a *basic* set of applications with specific SLAs and specific security and authentication policies.

Building Blocks:

Step 3

Once the network operator has validated authentication and SLA policies and VNF performance levels, it starts to leverage both network- and customer-facing analytics to upsell specific users on demand or targeted upgrades for new services and applications. The user accepts these offers via the EaaS portal and could even be potentially offered a number of charging options (on-demand, usage or bill integration)

Building Blocks:



Integra Profile

This section of the white paper profiles Integra, a fiber-optic backbone facilities-based North American cloud and enterprise service provider with one of the largest wholly owned fiber-optic networks in the western U.S. Along with its subsidiary Electric Lightwave, Integra provides reliable, low-latency connectivity to more than 100 data centers over diverse metro and long-haul fiber routes. Built from the ground up and designed for resiliency with redundant routers (dual core and dual aggregation), this enterprise-class network infrastructure serves enterprises, government, wholesale and some of the region's biggest content and technology providers.

We selected Integra because it supports a diverse portfolio of applications and services, including Ethernet and wavelength services, high-speed Internet, IP/MPLS VPN solutions, dark fiber, private line, cloud-based hosted voice services, cloud firewall, SIP trunking, conference calling, and unified communications and messaging services. Additionally, in the past year, Integra enhanced its high-bandwidth data transport capabilities with a set of Express Routes that provide point-to-point 100 Gbit/s wavelength connectivity between key metro areas in the West. Given this broad range of services, coupled with its uniquely deep and dense fiber footprint, Integra has also developed a progressive cloud data center and vCPE strategy, allowing it to deploy technology that continues to build upon its already agile and efficient network by adding well-orchestrated functionality via vCPE to meet future customer needs.

To develop this profile, we interviewed **Steve Fisher, Vice President, Network Planning and Security**. We started the interview by requesting input into the technical and business drivers Integra viewed as shaping and driving Integra's approach to technology with regard to cloud and vCPE strategies for both hosted and enterprise customers. According to Fisher, the two key drivers for its aggressive stance toward vCPE are reducing opex and streamlining CPE service delivery and support. This is because from a business perspective, Integra identified early on the need to reduce the business costs of supporting CPE for enterprise customers. To accomplish this, it has first focused on using vCPE to reduce the number of truck rolls to lower implementation costs and provide a clear and easy upgrade path for its customers.

From a technical perspective, Integra views vCPE as an enabling technology, delivering much-needed capabilities to empower customer interaction with CPE in a more straightforward way. Combined with the strengths of Integra's reliable, best-in-class network architecture, vCPE delivers added value to its customers. According to Fisher, this translates into providing additional software-based tools that allow customers to make their own changes to vCPE, resulting in shorter time to turn applications up and down. Says Fisher: "To accomplish this we must leverage virtualization to achieve automation. Automation of services via vCPE is key. This moves us to a zero touch services model which not only reduces truck rolls, it makes it possible for us to simplify enterprise and cloud hardware evolution and software upgrades."

However, while Fisher considers the truck-roll use case as an immediate driver for vCPE, Integra has already started looking to leverage vCPE's benefits to innovate and increase flexibility in more advanced use cases. According to Fisher: "We see vCPE as driving new revenue opportunities that we can't support today. An example of this is adding new capabilities for enterprise customers, on a permanent or temporary basis. A use case would be to sell basic enterprise connectivity, and then later add a software-based firewall. Since it is software-based, we can turn this up in real time to meet customer demand. Adding this capability today is both expensive and time-consuming."

Fisher sees this vCPE model being extended to transform security and other advanced services: "Security is increasingly a concern we hear about from our enterprise and hosted customers. We need the ability to introduce new security capabilities in software. Today this is very difficult, since the software is built into a specific appliance, which limits interworking and makes provisioning new capabilities both potentially a hardware and software exercise. For us, the business opportunity is to integrate more applications in the cloud and at the edge of the network, so end users can get access to new applications tailored to meet their requirements vs. implementing a bundled application approach that is more difficult to modify as their requirements change."

However, Fisher noted that as vCPE evolves, it not only fundamentally changes how the end user gains more control and access to applications; it can also deliver similar positive benefits for the operators. The operator sees the opportunity to leverage vCPE to create more innovative tailored customer solutions and move to an on-demand software model as well.

According to Fisher: "We want to move to a model where we buy the software we actually need. Virtualization is a key part of the equation to make this happen. Today we are starting to see a number of our software vendors moving to a more decomposed VNF functional model. This means we have more control over the features we want to purchase, and [this] ultimately allows us to assemble new software-based service combinations in the cloud at the edge using a range of partners. This will also allow customers to pick and choose software functionality. Putting those pieces together in unique ways will change the industry. This also changes how we view our data centers. It allows us to move from a more connectivity-oriented model to a more holistic application delivery model."

Integra is also focused on taking advantage of virtual technologies to streamline and create a unified hybrid cloud for its customers. The additional benefit of vCPE with cloud data center integration, Fisher noted, is related to hardware utilization. "We also see vCPE and data center capex reduction opportunities going forward. Today we often have a less optimal level of hardware utilization to actual customer base. It's much more efficient to leverage a pool of compute resources you can use for any applications. This mean we can move away from buying compute resources on spec, to buying based on actual customer-driven resource demand requirements, just like the software model."

Finally, Fisher said that vCPE can also be leveraged to enhance the SLA enforcement process. Specifically, Fisher noted that there is a shift underway in the industry to leverage vCPE software to give customers a much more advanced, personalized view of application performance. "With the right technology, including more intelligent CPE software coupled with more advanced analytics, we can augment existing dashboards to provide much better insight into which applications the end users are consuming, and how they are performing, so we can tailor our offers accordingly. This is what we are currently working on. We have done several successful hosted PBX trials leveraging this approach, and we plan to officially launch this as a commercial offering soon."

These use cases are just the beginning of the opportunities that Integra expects to leverage with its strategy for integrating virtual technologies. With an intelligent network infrastructure engineered for speed, agility and reliability, and a rich portfolio of services and applications, vCPE promises to accelerate Integra's capabilities to offer more customized services to its customers.

Conclusion

vCPE is poised to indelibly change the nature and spirit of enterprise service delivery. These changes will be profound from both the technical and business perspectives. Accordingly, we believe the commercialization of vCPE will ultimately be a strategic proof point of the unbridled power that virtualization can deliver to accommodate the critical A-list drivers at which network operators must excel to ensure continued market success in the enterprise.