RAD*, working with Intel® components, technology, and partnerships, has developed a comprehensive vCPE toolbox based on communications service providers' needs as they roll out NFV-based services.

Overview

As long as virtualized networks were still being conceptualized and planned, conventional wisdom was that future physical customer premises equipment (CPE) will convert to a lean network interface. This made sense as long as the blueprint for virtualization was based on the assumption that all intelligence would be concentrated at the data center and the cloud.

As an early industry virtualization evangelist, RAD* established and maintained a dialog with carriers and service providers right from the beginning. What RAD learned from its discussions was quite different. In many cases, communications service providers (CommSPs) said that they would actually require more functions at the customer premises than they have had until now with routers. They said that they would need, for example, access redundancy (specifically over LTE), security capabilities, SD-WAN for cost reduction, and tools to assure quality of experience (QoE) and competitiveness with web giants providing over the top (OTT) applications. That being the case, the trimmed-down CPE, also known as a physical CPE (pCPE), will not fit many of the deployment use cases.

This led RAD to develop virtual CPE (vCPE) software and hardware specifically designed for the customer premises that would be able to serve as platforms for hosting the full gamut of applications operators will require as they smoothly roll out NFV-based services. RAD’s flexible customer-located virtualization platforms enable SDN-controlled, carrier-class, and assured underlay connectivity for SD-WAN overlay and premium value-added services. In addition, they are fitted with open architecture and standard APIs to help service providers avoid vendor lock-in.

RAD, working with Intel® components, technology, and partnerships, has developed a comprehensive vCPE toolbox for the customer edge that includes:

- Powerful, carrier-grade vCPE-OS operating system for third-party and RAD Universal CPEs (uCPEs) - L2/L3 NIDs with pluggable Intel® architecture (x86) server modules
- Enhanced white box platforms
- Pluggable SFP devices adding connectivity, acceleration, and monitoring functionalities to servers
- RADview management and domain orchestration
- D-NFV Alliance: pre-tested VNFs and apps
Challenge
For carriers, NFV promises new ways of delivering services—including services they have never been able to offer before—in a more agile, flexible way.

However, the pace of NFV implementation has been slow, as service providers are still figuring out the right plan for migrating from their current networks and service mix—a plan that would not strain their operations and, consequently, their bottom line. One key issue that service providers are struggling with is the proper virtualization network design to fit specific business needs, such as target markets and service offerings, access rates, available compute processing resources, and more. Another issue is orchestration and integration with business and operations support systems (OSS/BSS).

Current white box servers, for example, lack certain much-needed functionalities, such as performance monitoring, network interface options, and troubleshooting tools to ensure viable service reach, optimal performance, and QoE for business customers. Current performance monitoring (PM) and troubleshooting tools are characterized by low accuracy and low scalability that lead to high CPU consumption. These limitations also require service providers to implement workarounds, such as external boxes to provide broadband access where fiber is not available.

Solution
RAD's innovative vCPE toolbox supports virtualization at the customer edge and in the network for L2/L3 services. This diverse portfolio is designed to meet specific service provider needs:

- Cost-optimized vCPE for business services with license-based physical network functions (PNFs), such as routing, NID, tunneling, and performance monitoring
- Scalable solution, which allows operators to spin-up virtual managed services, from security to routing, SD-WAN to IT services, and much more
- Powerful, carrier-grade vCPE-OS operating system with open architecture for networking and virtualization on RAD's vCPE devices or third-party white boxes
- Whitebox+ delivers wire-speed networking performance while preserving CPU resources for instantiation of additional VNFs
- Pluggable PNFs to enhance any white box: MEF 2.0 NID, PM responder/generator, PDH/SDH/SONET uplink, TDM user interface, 1588 PTP GM

The vCPE toolbox is enhanced by the RAD D-NFV Alliance, an ecosystem of vendors and international system integrators specializing in new NFV applications. RAD pre-tests and certifies all Alliance partners' applications, which address mission-critical communications needs.

Figure 1. vCPE Toolbox¹
RAD’s innovative approach enables service providers to start with a white box uCPE that can host VNFs, and then later activate licensed-based PNFs (e.g., a NID or hardware-based router functionality). Alternatively, a customer can start with a L2/L3 NID, with a modular Intel architecture-based server added later for hosting VNFs as virtual machines and full uCPE functionality.

**Product Highlights**

RAD’s vCPE-OS operating system runs on any white box server and is pre-loaded in RAD’s vCPE platforms. Featuring a comprehensive management and security suite, it is unique in its convergence of key OS components of NFV infrastructure (including a KVM hypervisor, Open vSwitch,* OpenStack,* and other elements) with embedded networking capabilities and integrated drivers for LTE and Wi-Fi. In addition, it enables seamless integration of RAD’s PNFs, such as OAM, timing, TDM, DSL, and PON. RAD’s vCPE-OS is interoperable with open source management platforms and easily integrates with standards-based SDN controllers, orchestrators, and operations/business support systems (OSS/BSS) from major providers.

The ETX-2i offers advanced demarcation for SLA-based, MEF CE 2.0-certified and L3 business services, wholesale services, and mobile backhaul. It can also serve as a universal CPE (uCPE), Whitebox+, which enhances a pluggable Intel architecture server module with PNFs to enable superior performance for vCPE applications. The ETX-2i offers state-of-the-art NETCONF/YANG client-controller interoperability for configuration, performance monitoring and service activation testing, traffic management, full end-to-end service control and monitoring, full diagnostics, and service turn-up. The key differentiator of the ETX-2i is the optional plug-in Intel architecture-based virtualization card, a module based on Intel® Core™ i7 and Intel® Atom® processors, which can host multiple VNFs from various vendors. This hybrid device offers the critical components and options needed in PoP or customer premises equipment.

An Intel architecture-based plug-in module for hosting virtual functions and applications can generate standard and value-added services, including:

- Routing
- Diagnostics and testing
- Firewall
- Intrusion detection and prevention
- Antivirus
- Encryption/VPN
- WAN optimization
- IP telephony

Another element in RAD’s vCPE toolbox is the ETX-2v, a new carrier-grade white box supporting a wide range of business customers and user scenarios, from small offices to large sites, using a variety of bandwidth and processing power options. It enables flexible operation of multiple VNFs running locally.

The RADview management and orchestration solution converges the management of both physical and virtualized entities and can be used by customers or service providers for end-to-end operation control of multi-site, multi-customer networks. An open API facilitates automation with higher layer orchestration and OSS/BSS systems.

RAD’s vCPE toolbox incorporates a number of Intel-supported technologies, including:

- **Data Plane Development Kit (DPDK)** – DPDK is a Linux Foundation project supported by Intel. The DPDK software library routes network packets around the Linux* OS kernel and vSwitch. Coupled with network drivers and an optimized run-time environment, significant network performance can be achieved compared to a classical virtual environment.

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**Virtualized platform for Value Added Services:**

**Built-in functions**
- Carrier-grade services
- SDN-controlled
- Overlay services
- Resilience solutions
- Performance monitoring
- Acceleration
- Etc.

**Flexible pluggable interfaces:**
- A/VDSL
- GPON
- Ethernet
- EoE1/E3
- LTE
- G.Fast
- WiFi
- EoSTM-1

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**Figure 2.** What kind of CPE will get the job done?¹
• **Intel® QuickAssist Technology** – offers easy integration for built-in accelerators, employing a hardware-assisted security engine for implementing major security processes. It accelerates and compresses cryptographic workloads by offloading the data to hardware capable of optimizing those functions.

• **Hyperscan** – an optimized pattern-matching library that can be used to detect large numbers of patterns in blocks or streams of data. It is especially useful in security applications such as intrusion prevention (IPS), antivirus (AV), unified threat management (UTM), and deep packet inspection (DPI).

### VNF Implementation Options

RAD offers service providers a wealth of alternatives to implement different software-based VNFs (as virtual machines or containers) and hardware-based PNFs (as integrated HW or pluggable devices).

**Figure 3. Variety of VNF Implementation Options**

- VNF as a Virtual Machine
- VNF as a Container
- Pluggable PNF
- HW Engine

**Figure 4. SD-WAN Enablement Platforms**

**Conclusion**

The customer edge is the optimal place for many networking, security, and value-added applications.

RAD, the industry pioneer of network edge virtualization, provides flexible vCPE toolbox for the customer edge and a complete solution to fit diverse performance, cost, and security needs.

RAD's vCPE toolbox also provides a convenient means for enterprises to experiment with NFV technology in a setting that leaves them fully in control and provides them with needed experience for scaling these functions into the cloud.

Intel's platform and supported Linux enhancements provide the hardware and software necessary to operate at the speeds required by high-speed networks.
Benefits
RAD’s vCPE toolbox...

- Minimizes capital expenditure in data centers prior to vCPE service launch
- Optimizes CPU and FPGA resource usage to maximize speed and application performance
- Increases flexibility related to the ability to host VNFs anywhere
- Provides an invest-as-you-grow model, with customer-edge compute resources expanding as more users are connected
- Maintains local policy, security, and access control on premises
- Is a scalable solution, allowing operators to spin-up virtual managed services, from security to routing, SD-WAN to IT services, and much more
- Preserves established network operations procedures, avoids extra boxes

About RAD
RAD is a global telecom access solutions and products vendor. Since 1981, RAD has pioneered innovative technologies that are designed to boost performance and improve the way service providers compete. For mobile, business and wholesale service providers, RAD offers award-winning Service Assured Access solutions, delivering better QoE (Quality of Experience), service agility and complete visibility of network performance to reduce churn, minimize time to revenue and enable greater operational efficiency. Having run Distributed NFV (D-NFV) PoC (Proof of Concept) testing with major carriers since mid-2013, RAD has become the industry leader in virtualization at the customer edge, allowing fast provisioning of value added offerings and low risk, cost effective migration to programmable networks. RAD has an installed base of more than 15 million units and works closely with Tier 1 operators and service providers around the globe. RAD is a member of the $1.35 billion RAD Group, a world leader in communications solutions.

About Intel Network Builders
Intel Network Builders is an ecosystem of independent software vendors (ISVs), operating system vendors (OSVs), original equipment manufacturers (OEMs), telecom equipment manufacturers (TEMs), system integrators (SIs), enterprises, and service providers coming together to accelerate the adoption of network functions virtualization (NFV)-based and software-defined networking (SDN)-based solutions in telecom networks and in public, private, and hybrid clouds. The Intel Network Builders program connects service providers and enterprises with the infrastructure, software, and technology vendors that are driving new solutions to the market. Learn more at http://networkbuilders.intel.com.