Boosting the uCPE White box with Carrier-Class Capabilities

Operators are looking to deploy agile services on demand based on generic white box platforms and a rich assortment of powerful software Virtual Network Functions (VNFs) that can be dynamically added, removed and chained to deliver differentiated service offerings without the risk of vendor lock-in. The beauty of white boxes is that they are general purpose, low-cost and easy to commoditize, but the problem is that they lack many of the specialized functions and interface options that cannot be virtualized. Pluggable physical network functions (P-PNFs), typically delivered in an MSA compliant SFP format, can provide the required physical interfaces, programmable hardware capabilities and specialized components to help close these gaps on an "as needed" basis and in a consistent manner, across multiple white box platforms.

This paper describes how service providers can augment uCPE White box servers with carrier-class service demarcation and performance assurance capabilities. This includes the ability to deliver premium, SLA-based L2 and L3 services combined with advanced diagnostics capabilities to detect, localize and troubleshoot network and NFVI/VNF performance issues.

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Introduction

Standard off-the-shelf, general purpose servers based on Intel architecture have become the common data center compute platform, as virtualization consolidates an increasing number of applications, workloads and services that once ran on proprietary architectures, into the cloud.

Now, as the vision of open-compute platforms in the data-center turns into reality, the industry is shifting its attention towards a converged platform for the network edge. A place where system architects have long pursued the universal platform for customer premises: the software programmable black or white box that can be changed on the fly to be any, or many network elements. But just how does that translate to the network edge, and in particular for customer premises equipment providing the Network Function Virtualization Infrastructure (NFVI) for virtual enterprise CPE (vE-CPE)?

Although standard IT servers may be considered for the deployment of vE-CPE on customer premises, white box appliances offer a significantly reduced CAPEX alternative for deployment in volume. Advantech's Universal CPE (uCPE) white-box offering embraces CSP NFV strategies and enables a more cost effective separation of hardware and software in the provisioning of zero-touch appliances installed at customer branch offices. Virtualized appliances may be run directly on bare metal or hosted as VMs or containers by an operating system such as RAD's Linux–based vCPE-OS with its open management interfaces, carrier-class NFV infrastructure with acceleration and integrated networking capabilities.

uCPE enhanced with RAD's vCPE-OS is indeed "universal" in that it not only enables elegant service-chaining of multiple virtualized functions but also provides complementary networking capabilities such as switching, routing and software-based performance monitoring.

As attractive as uCPE may be, current challenges hinder wider adoption, specifically, networking capabilities and mandatory operational functionalities. They lack, for example, accurate network and NFVI/VNF performance monitoring, network interface options to fit any available access and advanced troubleshooting tools to ensure viable service reach, optimal performance and QoE for business customers. Current software-based Performance Monitoring and troubleshooting tools are characterized by low accuracy and low scalability that lead to high CPU consumption, especially for functions such as service activation testing (SAT). These limitations also require service providers to implement workarounds, such as external boxes to provide broadband access where fiber is not available.

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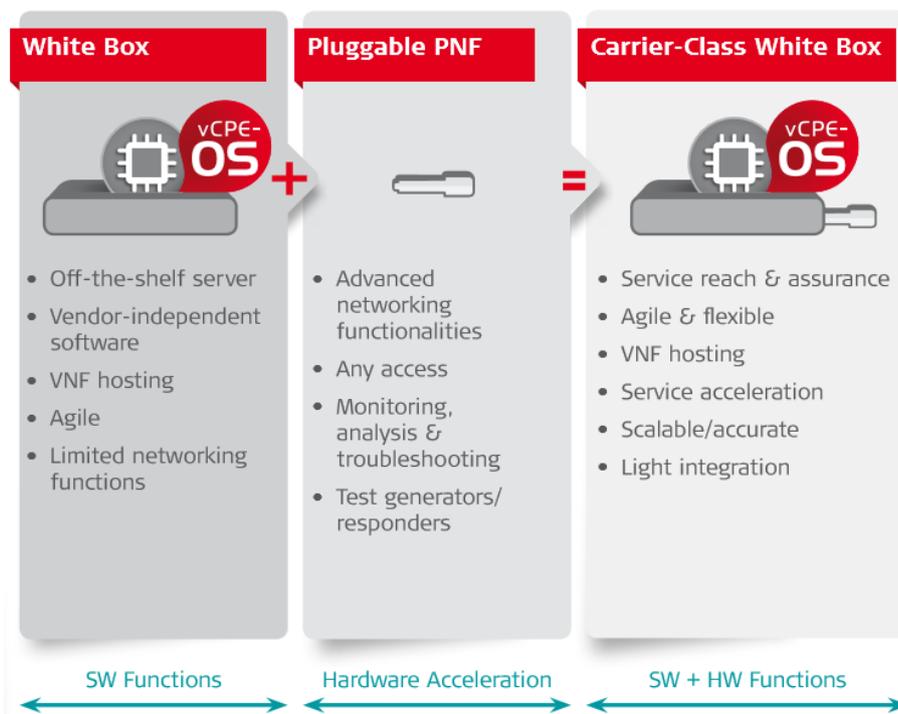*Your Network's Edge*

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Further Augmenting the uCPE with P-PNFs - on an as needed basis

Service providers are gradually learning that there's no need to settle for poor performance due to deficient functionalities or undertake huge upfront investments to compensate for them. Instead of network build-ups/forklifts and deployments of additional appliances, missing networking capabilities that cannot be properly implemented in software, can nevertheless be deployed – on an as needed basis – with smart SFPs that serve as pluggable physical network functions (P-PNFs). These P-PNFs can enhance the "universal" CPE with universal connectivity options by incorporating TDM, GPON, DSL, GPS and other physical interfaces as well as other hardware functions such as programmable FPGAs and OCXO timing components that are typically not available on COTS white box servers. RAD's vCPE-OS further differentiates itself by providing intelligent management of these P-PNFs.

Recent innovations in smart SFPs offer some interesting – and unique – capabilities that are added with minimal effort:

- Carrier-class service demarcation and performance assurance capabilities
- Network interfaces, such as xDSL (VDSL, SHDSL, etc.) and GPON
- Ethernet over TDM using standard GFP or HDLC framing
- IP over PPP/MLPPP over TDM
- TDM circuit emulation
- IEEE 1588-2008 (PTP) Grandmaster with built-in GPS/GNSS receiver

Such pluggable PNFs do not require separate power, cabling, rack space, or other OpEx-intensive resources, yet they ensure function consistency across multiple hosting devices. "Buy-as-you-need" networking functionalities with management integration ensures a successful vCPE deployment and helps carriers rapidly deploy new applications, services and infrastructure to quickly meet their changing requirements.
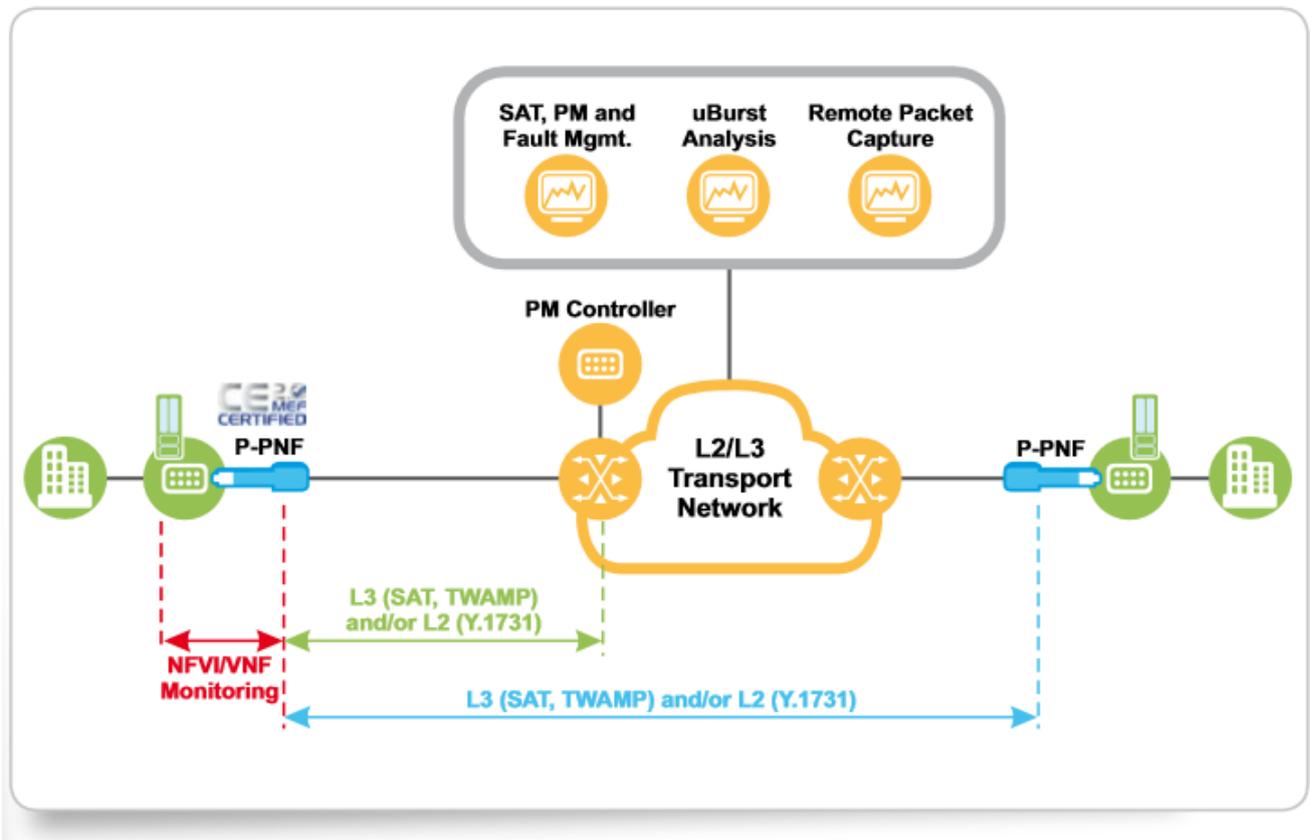

Boosting white box performance with pluggable PNFs

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The next section elaborates on a key P-PNF called the MiNID that augments CPE White box servers with carrier-class service demarcation and performance assurance capabilities. This includes the ability to deliver premium, SLA-based L2 and L3 services combined with advanced diagnostics capabilities to detect, localize and troubleshoot network and NFVI/VNF performance issues.

MiNID P-PNF for Service Demarcation and Performance Assurance

Service providers can deploy a P-PNF to deliver premium, SLA-based L2 and L3 services with improved network visibility and diagnostics. For example, by augmenting the uCPE with MiNID P-PNF, service providers can benefit from:

- Full **MEF CE 2.0 NID** functionality without consuming CPU cores or memory
- Comprehensive **traffic management** incl. flow classification, tagging, 2R3C and MEF 10.3 policing
- **Service activation/verification testing (SAT)** – <u>scalable</u> to line rate (irrespective of packet sizes)
- **L2 and L3 performance monitoring** (Y.1731/TWAMP) - utilizing <u>accurate</u> hardware timestamps
- Active **NFVI/VNF monitoring** to identify connectivity and VNF "freezing" or performance degradation
- **Fault detection** with Power/Network/NFVI/VNF threshold crossing notifications
- Deep **network visibility** with fine resolution Bandwidth usage and uBurst monitoring
- Advanced **troubleshooting tools** including Wireshark compatible Remote Packet Capture
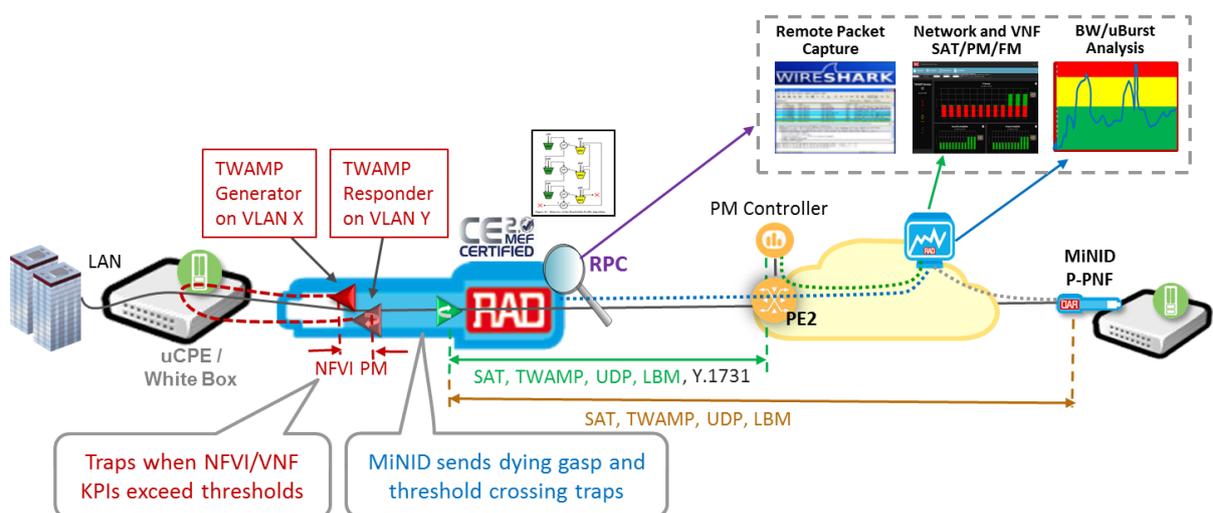

Service demarcation and performance assurance P-PNF

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Deriving Value from MiNID P-PNF in uCPE/White box

P-PNFs, whether added before service installation or later for troubleshooting purposes should ideally work "out of the box" with no need to customize per install or require field technicians to configure dedicated IP addresses, VLANs, etc. The sections below outline a phased deployment approach that provides maximum value with minimum installation or integration effort:

1. **"Autoresponder" -** This is the simplest scenario where a centralized PM Controller can initiate service activation tests and continuously monitor and report circuit performance. MiNID functionality includes:
   - Auto-detection of physical port settings for simpler installation procedures
   - No configuration or IP address required
   - VLAN agnostic L2-4 loopback and LBM/TWAMP autoresponder with accurate HW-based timestamps
2. **Bandwidth Analysis** – Access to the MiNID is required in order to retrieve status and statistics. This information helps troubleshoot and provides valuable insight into customer bandwidth usage patterns for upselling and bandwidth on demand services.
   - Unique "host loaned IP" mechanism eliminates need for separately configured IP address
   - Fine resolution Bandwidth Usage, Loss and uBurst reporting
   - Efficient statistics collection: TFTP/SFTP or SNMP from RADview or 3rd Party PM Portal
3. **MEF CE 2.0 Certified NID** – Eliminates need for separate Carrier Ethernet NID
   - Flow classification, tagging, policing, MEP instantiation, etc.
   - RADview or 3rd Party PM Portal collects L2 KPIs (delay, jitter loss,..)
4. **Monitor NFVI/VNF performance** – identify NFVI/VNF service chain performance
   - Threshold crossing traps when VNF "freezing" or performance degradation is identified
   - Remotely activate performance verification tools during maintenance windows when load is light
5. **Remote Packet Capture (Wireshark compatible)** – Interactive, bi-directional packet capture for detailed drill-down analysis and troubleshooting with quick access to the data of interest
   - On-demand or continuous capture with real-time view or storage in PCAP format
   - Superb customer experience using Wireshark GUI (instead of proprietary tools)
6. **End-to-end service verification testing and performance monitoring**
   - MiNID initiates wire-speed service activation tests and generates Birth certificate
   - Ongoing TWAMP based PM with loss, delay and jitter statistics
   - Dying Gasp and threshold crossing Traps sent to Fault Mgr.

Service demarcation and performance assurance functionality (color-coded)

Advantech's Universal CPE (uCPE) white-box offering

Every feature in Advantech's FWA-1010VC has been carefully selected to balance, performance, flexibility and cost. It is available in 4 or 8-core Intel® Atom™ configurations, ensuring that the right performance level can be matched to the workload at hand. 2-core versions are available on request for the most cost sensitive applications with moderate performance requirements.

Support for DPDK on all network interfaces provides up to 10x in packet throughput.
Integrated Intel® QuickAssist Technology accelerates execution of crypto algorithms without burdening the CPU. As a result, secure branch connectivity including end-to-end encryption can be provided without compromising VNF performance or increasing cost.

An integrated Trusted Platform Module (TPM) acts as a root of trust and can be used for secure key storage.

Availability & Reliability
Designing for cost does not necessarily mean sacrificing reliability. The FWA-1010VC comes with ECC memory support which is an essential feature for supporting server availability, a crucial element in providing enterprise customers with stringent SLAs.

For advanced availability, minimum downtime and lowest mean time-to-resolution, the FWA-1010VC supports dual SSDs. While the first SSD contains the active configuration, applications and other data, the second SSD may be used as a cost effective way to provide an emergency OS image supporting "Call home" functionality and offline diagnostics.

Connectivity
Four integrated copper LAN ports supporting auto crossover cabling (MDX) can be used to connect devices on the LAN. These ports are connected to an integrated Gigabit Ethernet SoHo switch inside the FWA-1010VC. The unit can also integrate a WiFi module with 2x2 MIMO support to provide access point functionality.

Two GbE ports support copper (RJ45) as well as standard fiber media (SFP) providing maximum flexibility in connecting to existing on-premise infrastructure without external media converters. An additional 10/100/1000Base-T Ethernet port on the unit can be used for additional LAN connectivity or the implementation of a DMZ.

The option to add LTE wireless connectivity can be used to implement service availability using LTE as a backup network or to support broadband wireless access in remote locations. In deployment scenarios using wireless connectivity via the integrated modem socket, the SIM card can be inserted via a small, removable plate. The simple installation procedure can be handled by untrained users.

In contrast to externally attached wireless dongles, it also secures the SIM card within the unit to avoid unwanted removal which would result in end customer service interruptions and increased support efforts for the service provider.

Dual-media WAN, Wireless, WiFi and copper LAN ports support allows the FWA-1010VC to span complete rollouts no matter which infrastructure is present in a given location. This helps to not only streamline logistics and service models but also to offer significant benefits in terms of life-cycle management and total cost of ownership.
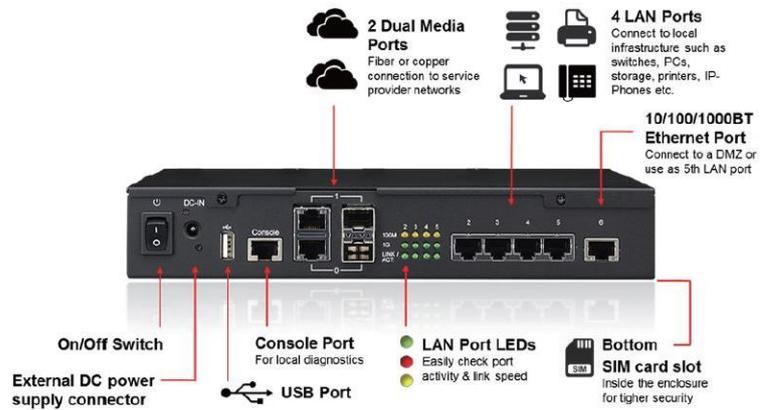

Figure: Advantech FWA-1010VC uCPE White box

RAD's MiNID - Pluggable NID and PM PNF to enhance any uCPE white box

MiNID® is a field-programmable miniature L2/L3 network interface device (NID), available as a pluggable smart SFP. It enriches any white box and uCPE with software-defined functionalities for enhanced demarcation, remote monitoring, fault isolation, and more. The MiNID increases operational efficiency and lowers service delivery costs. It features zero-touch provisioning for fast and simple installation and does not require dedicated space, power, or cabling.

MiNID helps deliver SLA-assured L2/L3 services with improved network visibility and diagnostics. It is a CE 2.0-certified NID with flow classification, tagging, 2R3C and MEF 10.3 policing but it provides many additional functions including Service activation tests (Y.1564), L2/L3 performance monitoring (Y.1731/TWAMP) with accurate hardware–based timestamping and offers deep network visibility with granular analysis of bandwidth usage and micro-bursts. Additional diagnostic capabilities include remote packet capture, threshold crossing and dying gasp traps.

MiNID further complements white box uCPE by providing active **NFVI/VNF monitoring** to identify and troubleshoot connectivity and VNF "freezing" or performance degradation issues.
The MiNID® is available in various form factors as shown. The SFP and SFP sleeve form factors are particularly relevant to uCPE white box deployments because they eliminate the need to deploy clumsy and expensive multiple box solutions. MiNID's programmability is based on a powerful FPGA that enables field updates to the product software and application.
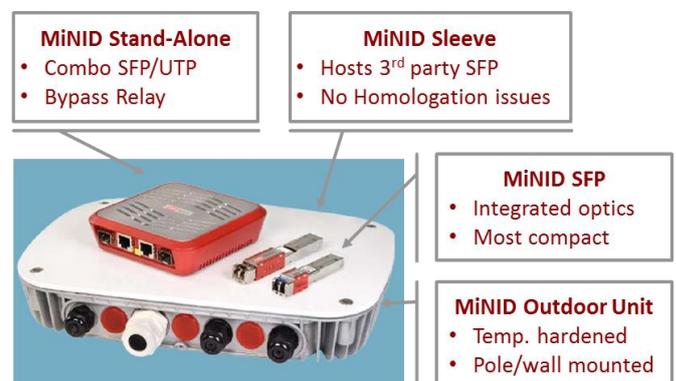

Figure: RAD MiNID – Various Form Factors

RAD vCPE-OS - Powerful, carrier-grade vCPE operating system for any white box

RAD's vCPE-OS combines powerful networking capabilities with virtualization for hosting SD-WAN and any other value-added virtual network function (VNF) applications from any vendor. Featuring open architecture, 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. It runs on any white box server.

Featuring a comprehensive management and security suite, vCPE-OS 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 pluggable physical network functions (PNFs), such as OAM, Timing, TDM, DSL, and PON.

Conclusion

As the industry is making steady progress towards network functions virtualization and software defined networking, service providers are cautiously setting up their migration plans to address the reality of their network assets. And while the IT-centric white box servers are transitioning to the carrier domain, there are several performance and functionality issues that need to be resolved before they can deliver on their agility and automation promise. Smart SFPs that serve as pluggable PNFs can help resolve gaps such as service demarcation and performance assurance.

In addition, pluggable interface options can help bring universal access to uCPE. This is critical for the delivery of virtualizing business services that must reach a level of scale, economy and ease-of-deployment to reach deep into the business market with an increased service provider footprint to cover customer sites in a consistent way. Backed by strong management and OS tools, pluggable PNFs enable service providers to rapidly deploy white boxes at customer sites, with modular P-PNFs for every service need, ensuring smooth migration to NFV-based business services.

Together RAD and Advantech have successfully tested RAD's MiNID and vCPE-OS in Advantech's FWA-1010VC network appliances to provide operators with the carrier-class service demarcation and performance assurance capabilities they need to ensure their service level commitments to customers.

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