

# ADVA FSP 150 ProVMe

## Performance and Functionality Test Report

### Introduction

EANTC was commissioned by Intel under the Intel® Network Builders program to perform independent tests of the ADVA FSP 150 ProVMe (F2.6) solution.

ADVA's FSP 150 ProVMe combines an open platform for hosting of virtual network functions with multilayer business service demarcation in a single network element. We were engaged to verify ADVA's claims regarding integration of fiber-based business access solutions with open VNF-hosting platforms for Network Function Virtualization (NFV) of fiber-based business access solutions and open-source virtual infrastructure management (VIM) systems for Network Function Virtualization (NFV). ADVA claims that FSP 150 ProVMe can be configured with OpenFlow, OpenStack and Netconf/YANG-supporting Software Defined Networks (SDN) and NFV-centric networks, creating significant advantages over legacy proprietary solutions.

#### Test Highlights

- **Support for OVS and SR-IOV operation, SR-IOV halving latency in comparison**
- **Full line rate performance (1Gbit/s) in SR-IOV mode with IPv4 traffic for all packet sizes**
- **Full line rate performance (1Gbit/s) in OVS mode with IPv4/IPv6 traffic mix for packet sizes above 128 bytes**
- **VNF lifecycle management with OpenStack Juno Heat templates**
- **Automated connectivity management with Modular Layer 2 (ML2) plugin for OpenStack's Neutron**
- **Hardware-based performance assurance functions for network connectivity and VNF hosting do not consume compute resources**
- **Hardware-based precision time synchronization with slave clock independent of the traffic load**

In our series of tests we reviewed FSP 150 ProVMe's performance and functionality. EANTC confirmed that FSP 150 ProVMe can replace legacy customer premises routers with virtualized, integrated solutions, without sacrificing any of the functionality or performance.

Specifically, we covered three key capabilities:

- The VNF lifecycle management process was demonstrated with standard OpenStack Juno release showing the ability to openly integrate into typical NFVI architectures.
- The performance improvement promises of Single Root I/O Virtualization (SR-IOV) versus Open vSwitch (OVS) were evaluated and confirmed with a range of tests evaluating the forwarding performance.
- FSP 150 ProVMe can provide a wide range of hardware-based support functions improving performance without consuming compute resources. Our test cases verified Access Control Lists (ACLs), port mirroring, network clock synchronization and VNF-performance assurance functions running independently from the server.

As our evaluation showed, ADVA successfully combined its vast experience in manufacturing classic Ethernet-based CPEs with a solid NFV infrastructure based on the compact architecture of the Intel® Xeon® processor D family to construct a unique edge-based NFV solution with value-added hardware features.

### VNF Lifecycle Management

ADVA successfully demonstrated extensive lifecycle management with Brocade vRouter VNF including On-Boarding, VNF requirements allocation, Network service creation and Instantiation by using a standard OpenStack tool.

We started the test session by on-boarding a Brocade vRouter image by using both the command-line tool glance as well as via Horizon GUI and verified its presence in the image list, as shown in figure 1. ADVA used a Heat template to simplify the network service creation which covered

Image Name	Type	Status	Public	Protected	Format	Size	Actions
vMX-RE	Image	Active	Yes	No	QCOW2	1.0 GB	Edit
vMX-FPC	Image	Active	Yes	No	RAW	2.2 GB	Edit
vmohdd	Image	Active	No	No	RAW	103.9 MB	Edit
ESO__Nuage NSG__nuage_new_snapshot_1.qcow2	Image	Active	No	No	QCOW2	355.4 MB	Edit
Juniper_vSRX	Image	Active	Yes	No	QCOW2	2.9 GB	Edit
vProbe_v3	Image	Active	Yes	No	QCOW2	686.9 MB	Edit
nuage_snap	Image	Active	No	No	QCOW2	355.8 MB	Edit
ESO__Juniper vSRX__media-vsrc-vmdisk-15_1349-D69_7.qcow2	Image	Active	No	No	QCOW2	2.9 GB	Edit
Nuage	Image	Active	Yes	No	QCOW2	355.4 MB	Edit
Test_vRouter	Image	Active	Yes	No	QCOW2	36.4 MB	Edit
Forti	Image	Active	Yes	No	QCOW2	36.4 MB	Edit
Fortigate_latest	Image	Active	Yes	No	QCOW2	36.4 MB	Edit
Vyatta5.1	Image	Active	Yes	No	QCOW2	631.8 MB	Edit

**Figure 1: OpenStack VNF Image List**

all steps needed for the procedure. ADVA claimed that cloud-init and config drive are supported for VNF configuration. By using cloud-init, all configurations could be loaded during the VNF on-boarding process. In the config drive method, the configuration would be saved on an additional disk and loaded after the on-boarding process. Limitations in configuring the Brocade vRouter VNF with cloud-init could be solved by directly accessing the VM's console.

Service chaining requires connectivity to be established among VMs and from VMs to virtual and physical network interfaces. Connectivity is managed by the OpenStack's Neutron. As the FSP 150 ProVME combines virtual switching capability with physical switches, ADVA provides a mechanism driver interfacing with the ML2 plugin into Neutron for configuring end-to-end connectivity through virtual and physical switches in an automated way. Our tests revealed some differences in VLAN handling between SR-IOV drivers and the VM, which were solved by a script provided by ADVA.

We validated that the newly deployed Brocade vRouter functioned correctly by sending test traffic through the instance. Through these procedures ADVA demonstrated the simplicity of Lifecycle management by using standard OpenStack tools.

### Forwarding Performance

The forwarding performance can be verified for particular interfaces or for a whole device by measuring the

throughput and delay performance metric when the data traffic is transmitted into the interface or device at high load. The goal of our test was to find the performance of customer premises equipment (FSP 150 ProVME) virtual switch coupled with a Network Function Virtualization Interface Platform based on Intel Xeon processor D family.

The test was performed with a series of standard packet sizes ranging from 64 to 1518 octets based on RFC 2544 section 26.1 and 26.2, as well as a mix of packet sizes realistically resembling typical Internet traffic (IMIX). The IMIX used in the test is defined as a proportional mix of several frame sizes as specified in Table 1 below.

Frame Size [bytes]	Weight	Percentage
IMIX for IPv4		
64	3	4.8%
100	26	41.3%
256	6	9.5%
570	5	7.9%
1300	6	9.5%
1518	17	27.0%
IMIX for IPv6		
128	29	46.0%
256	6	9.5%
570	5	8.0%
1300	6	9.5%
1518	17	27.0%

**Table 1: IMIX Composition**

In this series of tests we measured the throughput and latency metric when the data traffic is transmitted into the FSP 150 ProVME at high load. We wanted to show what base line performance can be expected from OVS and SR-IOV in NFV setup. For the performance verification we tested with a series of simple services, with one and two VNFs in a chain as described in figure 2. As a result, the total forwarding performance of the platform depends on how many services had to be operated in order to create the desired service chain. As in figure 2 the test traffic was transmitted through a single VNF as well as a service chain with two VNFs. For this purpose ADVA used Brocade vRouter as a VNF to create a service chain and to forward the IP traffic between two interfaces. In this test case we did not analyze the performance of Brocade vRouter.

ADVA's FSP 150 ProVME platform offers two options to connect the VMs, namely Open vSwitch (OVS) and SR-IOV (Single-Root I/O Virtualization). OVS provides a fully functional switch implementation in software and is capable of stripping the VLAN tag, therefore the VNF did not require specific VLAN configuration.

On the contrary, SR-IOV bypasses the OVS and connects the VNFs directly to the physical ports and enables multiple VNFs to share PCI hardware resources. SR-IOV is designed to have the performance similar to PCI pass-through, but allows multiple VMs to be connected via same network interface, separated by VLAN. In the SR-IOV setup, the traffic arrives with VLAN tag at the VM. Our SR-IOV testing focused on IPv4 traffic while ADVA worked on resolving the problem with VLAN tagged IPv6 traffic on the Brocade vRouter. However, we performed the

OVS test with IPv4 and IPv6 traffic. The test scenarios are categorized as follows.

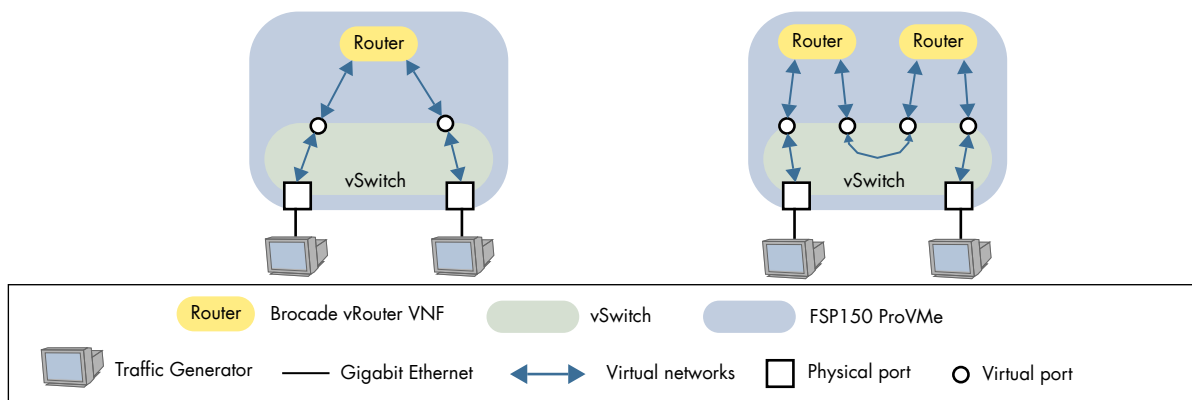
Test	VNFs	vSwitch	Traffic
1	1x VNF	OVS	IPv4+IPv6
2	2x VNF	OVS	IPv4+IPv6
3	1x VNF	SR-IOV	IPv4
4	2x VNF	SR-IOV	IPv4

**Table 2: Test Scenarios – Forwarding Performance**

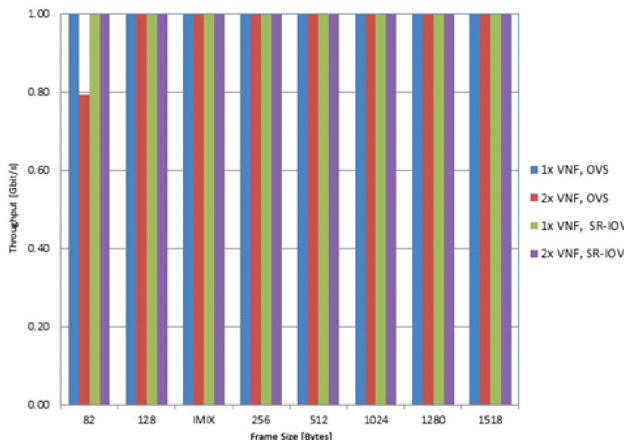
The test setup consisted of a FSP 150 ProVME and an Ixia traffic generator. We connected two Ethernet ports to the physical ports and simulated bidirectional IP test traffic at the target traffic transmission rate of 1 Gbit/s between two ports of FSP 150 ProVME using IxNetwork software. By using RFC2544 test methodology, we found the throughput value for each of the frame sizes by locating the maximum traffic rate where no loss occurs through binary search. At the same time, we measured the latency achieved at the maximum bandwidth. The goal of the test was to find the performance metric of OVS and SR-IOV solutions in ADVA's FSP 150 ProVME platform.

We achieved full line rate performance (1 Gbit/s) for all scenarios and packet sizes with the sole exception of the 2-VNF setup with OVS and 82-byte packets. This behavior is within expectations, as traffic consisting of small packets results in higher packet rate and relative processing overhead.

Parallel to the throughput, we measured the latency for each setup. As expected, the latency increases with the number of VNFs, as the packets are passing more segments in the service chain (see figure 4 and 5). Also as expected, SR-IOV achieves



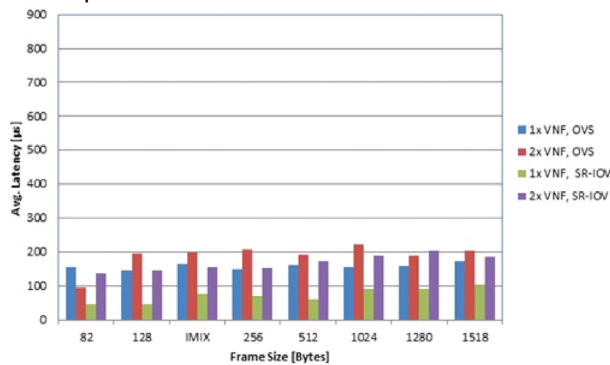
**Figure 2: VNF Chaining – Forwarding Performance**



**Figure 3: Throughput Performance**

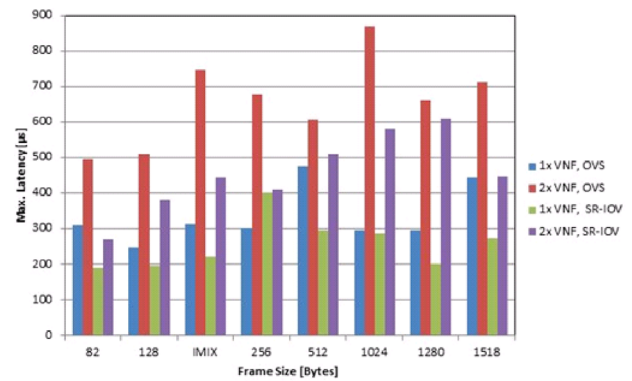
slightly lower latency due to bypassing the OVS. The increased number of interconnections leads to increased processing time for the switch process. OVS with two VNFs has the highest average latency for all the packet sizes; notably it was 224 microseconds ( $\mu s$ ) at 1024 bytes packet size (see figure 4). The lowest average latency (46  $\mu s$ ) was measured for SR-IOV with one VNF at 128 bytes packet size.

Figure 5 indicates that OVS with two VNFs has the highest maximum latency measurement at 1024 bytes packet size, which is 868  $\mu s$ . The lowest maximum latency is measured for SR-IOV with one VNF at 82 bytes and 128 bytes packet size, which is 192  $\mu s$ .



**Figure 4: Average Latency**

From figure 4 and 5 we can conclude that OVS has twice the latency of SR-IOV; with SR-IOV it can be clearly seen that latency scales linearly with the number of VNFs.



**Figure 5: Maximum Latency**

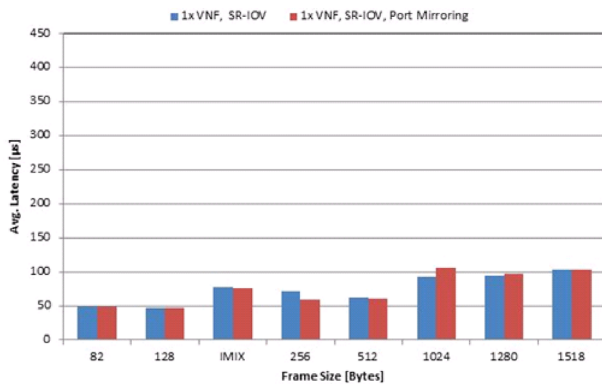
## Hardware-Based Support Functions

In addition to the high performance server, the FSP 150 ProVME provides a wide range of hardware-assisted support functions such as synchronization and service assurance. Those functions can be activated without requiring compute resources, hence, not creating any negative impact on the performance of revenue-generating VNFs. This advantage was shown with a series of tests demonstrating independence of firewalling with ACLs, port mirroring and synchronization from service performance. The test cases looked at the impact of service activation on VNF latency and analyzed any correlation between hardware functions and software appliances.

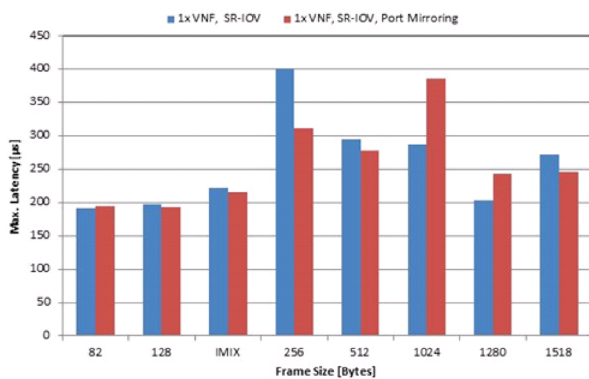
### Port Mirroring

ADVA's FSP 150 ProVME provides traffic mirroring functionality, where the entire traffic through a specific interface can be copied and sent to another physical or virtual interface. For this test, we set up an additional VM running plain Ubuntu and PCI Pass-through connection to Ubuntu VM for port mirroring. This test setup consists of one Brocade vRouter, SR-IOV and one Ubuntu VM. Using standard interface statistics and packet capture in Ubuntu VM we verified that FSP 150 ProVME mirrors the traffic during the test. At the same time we compared the test results with standard SR-IOV with a single Brocade vRouter test setup.

Data transmission was not significantly affected by using port mirroring at any frame size (see figure 6). We confirmed that FSP 150 ProVME reaches 100% throughput while using the port mirroring feature



**Figure 6: Port Mirroring - Average Latency**



**Figure 7: Port Mirroring - Maximum Latency**

In figure 7, the highest latency for port mirroring was observed at 1024 byte packet size, which was increased by 97 µs and also the value was increased by 40 µs at 1280 byte packet size.

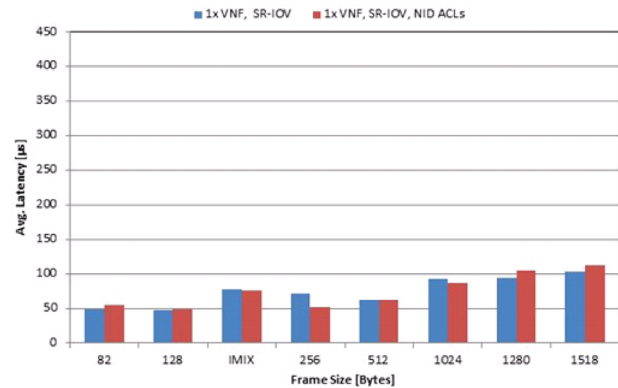
### Access Control List (ACL)

The Network Interface Device (NID) component of the FSP 150 ProVMe platform can apply ACL rules to the incoming and outgoing traffic. This can provide a simple but efficient alternative to a full-featured firewall, or help reduce the traffic load by filtering out undesirable traffic before it reaches the NFVI. The filtering rules are executed in the order defined by their priority value and can allow or deny ranges of MAC addresses, VLANs or IPv4/IPv6 addresses.

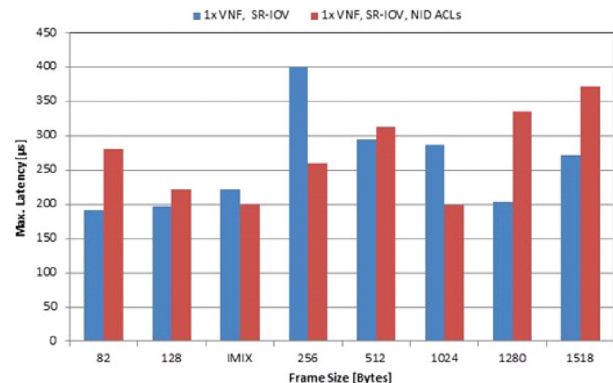
In our test, we defined a total of 20 rules, 10 for each access and network-side interfaces. These included 3 MAC-based, 2 VLAN-based and 5 IP-based rules. The rules were defined to allow our test traffic to pass, but not before the entire list was evaluated. We manually confirmed that the rules were in fact blocking matching addresses and then ran a regular throughput test. This test setup consists of

one Brocade vRouter, SR-IOV and the above mentioned ACL rules. We compared the test results with standard SR-IOV with a single Brocade vRouter test setup.

In figure 8 we can see that the average latency is increased by nearly 10 µs only at 82 bytes, 1280 bytes and 1518 bytes while using NID ACLs and at most frame sizes data transmission was not affected.



**Figure 8: ACL - Average Latency**



**Figure 9: ACL - Maximum Latency**

In figure 9, the maximum latency for NID ACLs was observed at 1518 byte packet size, which was increased by 100µs and also the value of NID ACLs was increased by 133µs at 1280 byte packet size. We confirmed that FSP 150 ProVMe reaches 100% throughput while using the ACL feature.

### Clock Synchronization

FSP 150 ProVMe platform provides synchronization delivery and assurance functions using Synchronous Ethernet (SyncE) and IEEE1588 Precision Time Protocol (PTP) to address timing requirements in mobile networks. It can act as a slave, boundary and master clock. In this test setup we measured the

accuracy of the slave clock synchronization with an external boundary clock and verified that the slave clock synchronization is not affected by the traffic load. The device provides pulse-per-second (PPS) signal and 10 MHz outputs which we used to measure both phase and frequency quality of the PTP synchronization.

Our test bed consisted of two interconnected FSP 150 ProVMe devices and a Calnex Paragon-X test equipment. One of the ADVA devices acted as a slave clock and the other as a boundary clock. Paragon-X has a GPS-fed grandmaster clock device and a Phase/ Frequency analyzer. All three devices use PTP and the grandmaster clock provides synchronization to the boundary clock, which it then relays to the slave clock. The PTP signal between the boundary and the slave clock ran in a separate VLAN over the same physical link as the test traffic. The quality of the frequency and phase synchronization was measured by the Phase/ Frequency analyzer. The analyzer received PPS and 10-MHz signals from both grandmaster and the slave clock. We used the G.823 E1 SEC and G.8271.1 masks as a requirement for frequency and phase synchronization and verified the long-term stability of the synchronization by running the measurement for 6 hours. Figure 10 depicts the test setup.

We started the test by allowing the boundary clock to acquire a lock via the GPS-fed grandmaster clock. Once it was locked, the slave started to lock to the Boundary Clock. PPS and 10 MHz signals of

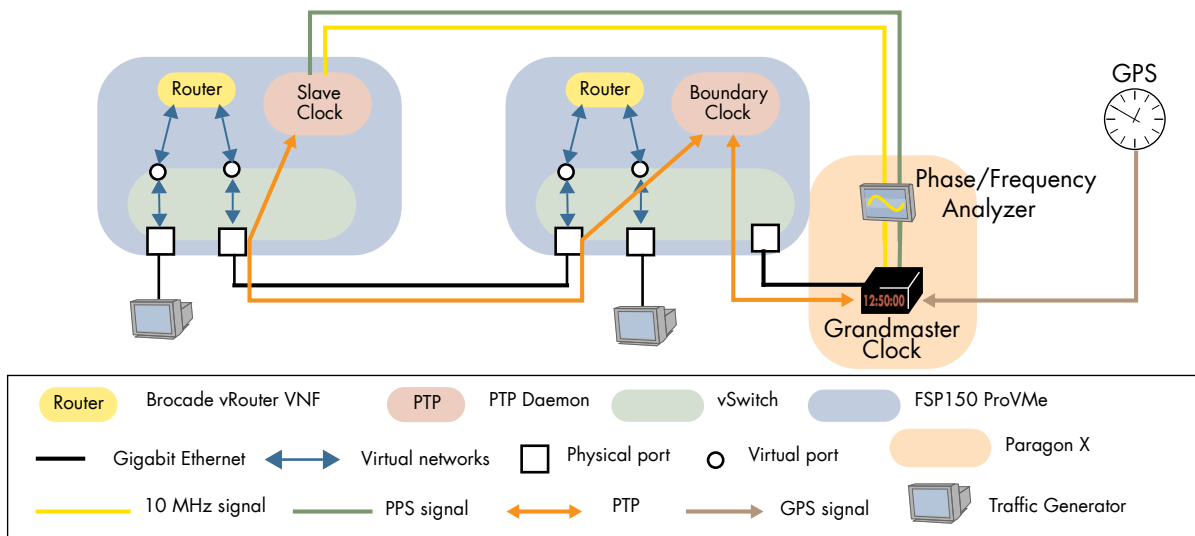
the locked slave clock were measured by the Phase/Frequency analyzer with grandmaster signals. We performed the test once with traffic load to verify that PTP synchronization was not affected by traffic running in parallel. To define the network load we used a network load profile from ITU-T G.8261, test case 13.

The measured average absolute time error of PPS signal was only -11 ns against the mask G8271 accuracy level 4 ( $\pm 1.5\mu s$ ) requirements of  $\pm 1.1\mu s$ . The measured maximum Maximum Time Interval Error (MTIE) value of the PPS signal was 14 ns and when traffic was added, it increased only by 44 ns and was still well below the mask.

As well as the measured maximum MTIE value of frequency was nearly 19 ns and during the traffic it increased only by 43 ns. All the measurements show that phase and frequency successfully synchronized with slave clock and the synchronization was not affected by the traffic load.

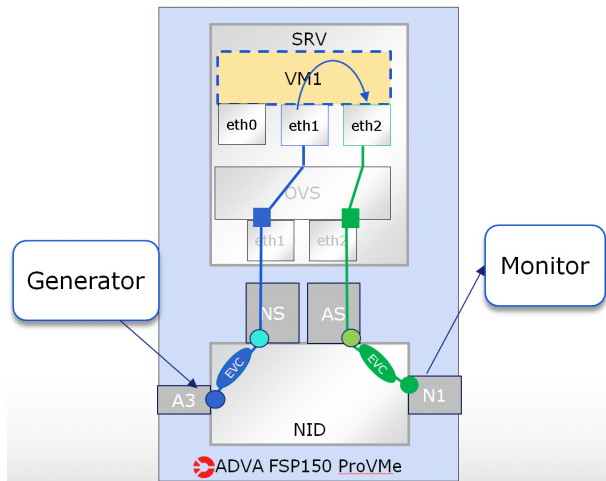
### VNF Performance Assurance Functions

The FSP 150 ProVMe provides a set of advanced assurance functions for VNF in-service monitoring. EECPA (Enhanced Ethernet Connection Performance Analysis) provides an integrated traffic generator/analyzer for synthetic performance measurements. EECPA performs measurements between the internal virtual ports, therefore using different reference points than the external Ixia analyzer. Due to a shorter data path which excludes the hardware NID



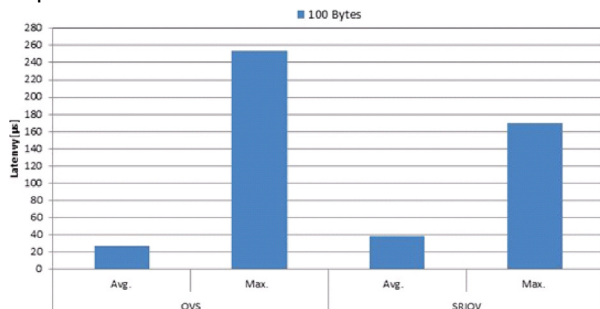
**Figure 10: Test Setup - Clock Synchronization**

component, the measured latency is lower, as expected.



**Figure 11: Test Setup - EECPA**

This case is applicable for one way testing of VM(s) in the embedded or external service while EECPA generator and monitor are implemented in the internal hardware as shown in the figure below. Since EECPA generator and monitor are located in the same Node test operation and delay measurement is tightly coordinated: same timestamp generator is used and test start and test end scheduling is simple.



**Figure 12: EECPA Latency Test Results**

In this test we used only one stream to generate 1Gbit/s IPv4 traffic with 100 bytes frame size. For the analysis we used the OVS and SR-IOV setup and measure the latency of EECPA measurement. We confirmed that FSP 150 ProVMe is able to generate test traffic at 100% throughput and measure the performance of the VNFs or Service Chain it is applied to.

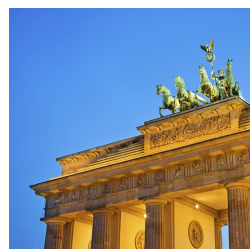
Figures 12 and 13 show examples of the test results measured by EECPA, showing how FSP 150

Test Stream A Configuration			
<b>Identification</b>			
Name:	stream-1		
<b>Configuration</b>			
Payload Type	: Fixed		
Frame Size	: 72 (B)		
Rate	: 1,000,000,000 (bps)		
MAC Source Address	: 00:80:ea:81:bb:b9		
MAC Destination Address	: fa:16:3e:55:b2:70		
IP Precedence	: None		
IP Priority	: 0		
IP Version	: IPv4		
IP Source Address	: 30.30.220.100		
IP Destination Address	: 30.30.100.100		
UDP Control	: Enabled		
UDP Source Port	: 5000		
UDP Destination Port	: 3000		
<b>VLAN Configuration</b>			
Outer VLAN	: Enabled	EtherType: 8100 (hex)	Tag: 1021-1
Inner VLAN1	: Disabled	EtherType: 8100 (hex)	Tag: 4094-1
Inner VLAN2	: Disabled	EtherType: 8100 (hex)	Tag: 4094-1
<b>Test Stream A Results</b>			
Start Time	: 2017-03-07 16:59:06		
Stop Time	: 2017-03-07 16:59:38		
Elapsed Time	: 30 (secs)		
Minimum Delay	: 35 (us)		
Maximum Delay	: 307 (us)		
Average Delay	: 47 (us)		
TX Frames	: 40476422		
RX Frames	: 40476422		
RX Average Bit Rate	: 999961661 (bps)		
RX Frames % Success	: 100.00		
Sequence Gaps	: 0		
Out of Sequence Errors	: 0		
Non-EECPA Frames	: 0		

**Figure 13: EECPA Test Configuration and Results**

ProVMe is able to measure the latency achieved through the service chain of VNFs provisioned on the unit.

## About EANTC



EANTC (European Advanced Networking Test Center) is internationally recognized as one of the world's leading independent test centers for telecommunication technologies. Based in Berlin, the company offers vendor-neutral consultancy and realistic, reproducible high-quality testing services since 1991. Customers include leading network equipment manufacturers, tier-1 service providers, large enterprises and governments worldwide. EANTC's proof of concept, acceptance tests and network audits cover established and next-generation fixed and mobile network technologies.

EANTC AG  
Salzuffer 14, 10587 Berlin, Germany  
[info@eantc.com](mailto:info@eantc.com), <http://www.eantc.com/>

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