

SOLUTION BRIEF

Network Function Virtualization



Introduction

The aim of this document is to give a comprehensive view of the Ekinops virtualization solution. It also describes how a service provider or system integrator can define new managed network services, how to create them and eventually how to provision them on a large scale.

We will start by describing the drivers for virtualization. The next chapters will highlight how Ekinops provides full turnkey solutions to get a virtualized network up and running in just a few days.

The enterprise network environment

Today network connectivity is undoubtedly one of the most critical assets in the large majority of enterprises. In particular, the following aspects of such an environment become increasingly important in almost any company:

- Network reliability and resilience
- Network performance, especially for business critical applications that are increasingly Cloud-based
- Network security
- Flexibility and agility in changing network requirements, such as opening new sites or changing performance or security requirements

Traditionally, these requirements have been addressed by using a multi-vendor multi-box solution, constituted of modems, routers, load balancers and security devices wired together, augmented with some company servers.

It is obvious that designing, installing and managing such a network is at best not obvious, and that applying changes to such environment usually requires onsite interventions, even outside office hours.

The virtualization alternative

The base of the virtualization solution for enterprise customers consists in using software instances instead of physical boxes (Value Added Services (VAS) implemented as Virtual Network Functions (VNF)) and interconnecting them using software defined (virtual) connections instead of using hard-wired connections. This means that instead of having multiple boxes, the whole enterprise networking solution can run on a single COTS (Common Of The Shelf) device, typically an x86 platform and commonly referred to as a universal CPE (uCPE).

Acronyms	
API	Application Programming Interface
Compose	(Ekinops) Brand name of the Ekinops software portfolio for turnkey solution
COTS	Commercial Of The Shelf: a product that is completely standard
CPE	Customer Premises Equipment
CPU	Central Processing Unit
DS	(Ekinops) Design Studio
EMS	Element Management System
LIM	(Ekinops) Local Infrastructure Manager: A local implementation of a VIM
NFV	Network Function Virtualization. The concept of making network functions virtual.
NFVI	Network Function Virtualization Infrastructure
NFVM	Network Function Virtualization Manager
NS	Network Service
NSD	(Ekinops abbreviation) Network Service Descriptor; a description of a network service design in XML format, including custom-specific parameters.
OM	(Ekinops) OneManage
OVP	(Ekinops) Open Virtual Platform. Series of uCPE from the Ekinops range
pCPE	Physical CPE
SBC	Session Border Controller
SMB	Small and Midsize Business
SP	Service Provider
uCPE	Universal CPE, based on a generic x86 hardware platform
VAS	Value Added Service
vCPE	Virtual CPE. A CPE which is implemented as a VNF, running on a NFVI (such as a uCPE)
VEP	(Dell abbreviation) Virtual Edge Platform; brand name of the Dell marketed uCPE series
VIM	Virtual Infrastructure Manager
VM	Virtual Machine
VNF	Virtual Network Function: an instance of a network function in its virtualized form. Examples include firewalls, routers, SD-WAN entities, etc.
YANG	Yet Another Next Generation. Data model structure, typically used (amongst other things) to describe configuration parameters and dependencies in an Orchestration environment

Following diagram shows a simplified view of such an architecture:

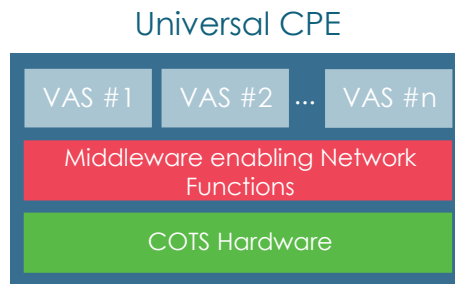


Figure 1 - Architecture simplified view

The transition from the “old world” with its multitude of pCPE boxes to a “new world” with a virtualized solution can be depicted as follows:

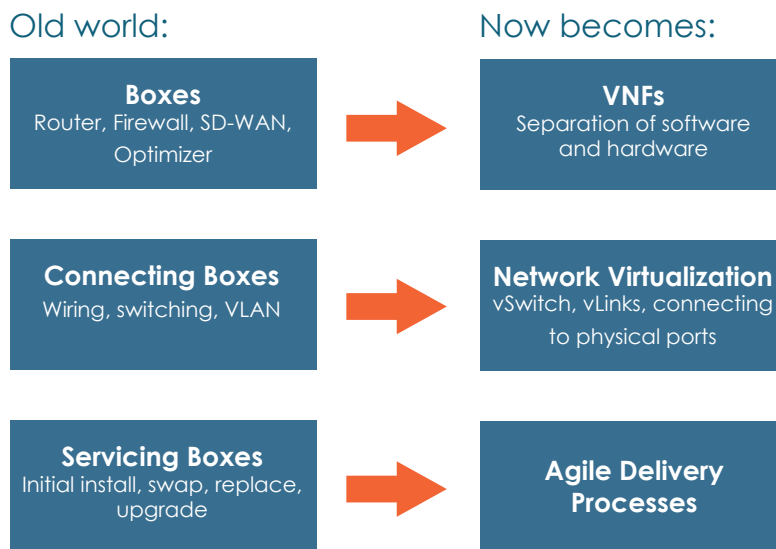


Figure 2 - Transition from “old world” to a “new world”

Virtualization benefits for service providers

In a virtualized model, delivering a managed network service solution will result in immediate benefits on the design, operation and maintenance for the service provider or system integrator offering such a service:

Eliminate truck rolls	Virtualization eliminates the need for deploying new hardware when adding Value Added Services or when upgrading the customer network.
Long-term CAPEX Optimization	Using a single common standard (COTS) hardware platform can reduce the overall hardware cost when different VAS are consolidated. By using software instances to deliver the different VAS, the VNF vendor can easily be replaced.
Flexibility Agility Time to Market	Enables a broad choice of services (VNF catalogue), independent of hardware. Delivery of a new service, or upgrade of an existing service happens with a single mouse click, without any field intervention

The Ekinops NFV Solution

Ekinops is a leading provider of physical CPEs, virtual CPEs and network functions enabling managed network services enterprise customers around the world.

Ekinops delivers the products and the associated services for the design, creation, validation and deployment of NFV based Network Services for operator-scale workloads.

On the hardware side, the solution relies on physical computing and networking hardware, based on an open x86 architecture, aka. a uCPE or whitebox.

On the software side, Ekinops offers its Compose portfolio, which includes middleware, services and managers to make networks software-defined. It is made of the following elements:

- The Compose middleware, called **OneOS6-LIM**, offering an open virtualization, service chaining and VNF (Virtual Network Function) lifecycle management environment. OneOS6-LIM also offers embedded enterprise routing and SD-WAN capabilities.
- Compose Services provide the functions that are needed for building the desired network service, and typically include routing, firewall, SD-WAN and SBC functionalities. The Compose services rely either on in-house VNFs and embedded functions, or it provides also access a certified third-party VNFs, which represents an open ecosystem of more than 30 certified VNFs (through the Ekinops Certification Program).
- The Compose management framework offers a most flexible and agile management system for an end-to-end management of virtualized services. It consists of a design-time environment and an execution-time environment:
 - The design-time environment allows defining, designing and creating Network Service Descriptors (templates). This solution is called **Design Studio**.
 - The execution-time environment allows the zero-touch-provisioning and management of the services programmed in the above design phase. This solution is called **OneManage**.

The software components listed above are making up the Ekinops Compose portfolio. They interact seamlessly with each other in order to provide a turnkey solution for networking, including virtualization and SD-WAN.

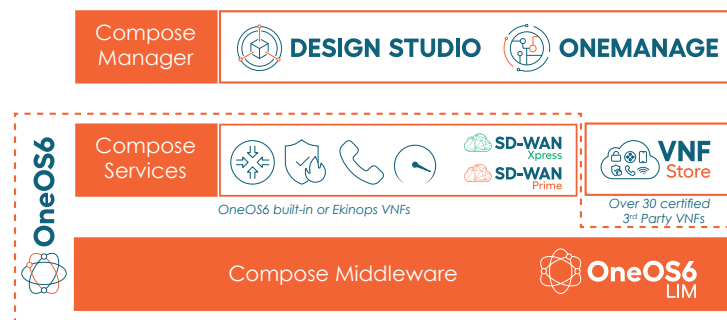


Figure 3 - The Compose portfolio for Access

The remainder of this document describes the above indicated components, including how they interact with each other.



The universal CPE (uCPE)

The uCPE or whitebox is the Network Function Virtualization Infrastructure (NFVI) or hardware on which the virtualization solution is built. It provides the resources for computation, storage and networking. Ekinops adopts a completely open approach for the support of these x86 based platforms. For this, Ekinops markets its own hardware series under the name OVP (Open Virtual Platform), but is also reselling and servicing the Dell VEP series and is open to support (almost) any choice of third-party hardware.

The Ekinops OVP uCPE series

Ekinops markets its uCPEs under the OVP name. The series goes from entry-level products with only 4 CPU threads up to 24 CPU threads. The following table gives a view on the available products in this range.

Availability	Code	Model	CPU Type	CPU Threads	10/100/1000 Base-T	SFP (1G)	SFP+ (10G)	Other	RAM	SSD	Redundant PSU
✓	71800	OVP404	Denverton C3558	4	6	2	-	-	8	120	No
✓	71842	OVP408	Denverton C3758	8	6	2	-	-	16	240	No
✓	71886	OVP408 LTE	Denverton C3758	8	6	2	-	LTE	16	240	No
✓	71843	OVP416	Denverton C3958	16	6	2	-	-	32	240	No
✓	71490	OVP808	Xeon-D1518	8	11	-	-	-	16	240	No
✓	71862	OVP824	Skylake-D2163IT	24	8	-	4	-	64	960	Yes

The Ekinops OVP uCPE series

Ekinops is an authorized reseller and service partner for Dell. From this perspective, Ekinops offers also hardware and OneOS6-LIM software support for VEP (Virtual Edge Platform) series:

Availability	Code	Model	CPU Type	CPU Threads	10/100/1000 Base-T	SFP (1G)	SFP+ (10G)	Other	RAM	SSD	Redundant PSU
✓	71826	VEP1425	Denverton C3558	4	6	-	2	-	8	120	No
✓	71822	VEP1445	Denverton C3758	8	6	-	2	-	16	240	No
✓	71824	VEP1485	Denverton C3958	16	6	-	2	-	32	240	No
✓	71763	VEP4600M	Xeon-D2145NT	16	4	-	2	-i	16	240	No
✓	71764	VEP4600M	Xeon-D2145NT	16	4	-	2	-	32	960	No
✓	71765	VEP4600L	Xeon-D2187NT	32	4	-	2	-	32	240	Yes
✓	71766	VEP4600L	Xeon-D2187NT	32	4	-	2	-	64	960	Yes

Third party uCPE

Thanks to the openness of the Ekinops OneOS6-LIM middleware, it is possible to support almost any third-party uCPE hardware. In this case, the uCPE is sourced directly by the service provider or system integrator. Many brands and models are already proven and working in combination with OneOS6-LIM.



The introduction of a new third-party hardware will need validation, as to make sure that the different hardware components are properly recognized and put to use by the OneOS6-LIM middleware. For this purpose, Ekinops offers a third-party benchmarking service, as described in a separate services document.

Compose middleware: OneOS6-LIM



OneOS6-LIM as hypervisor

OneOS6-LIM implements the role of the local hypervisor or Virtual Infrastructure Manager (VIM) of the uCPE (NFVI), and is effectively the cornerstone of the virtualization solution.

OneOS6-LIM is installed as a middleware Operating System (OS). As a hypervisor, it fulfills the following tasks:

- It controls and manages the available hardware resources of the uCPE (single NFVI-PoP). It allocates/releases uCPE infrastructure resources for the different hosted VNFs and embedded services.
- It handles the VNF lifecycle management, including the instantiating of VNFs, setting the onboarding parameters, doing the monitoring, etc.
- It manages the service chaining of different VNFs and embedded functions, in order to build a consolidated network service.
- It exposes a northbound open interface that supports management of the uCPE resources, VNFs, service chaining and all embedded functions. This interface also includes a fully modelled NETCONF/YANG interface.
- It provides a graphical user interface to support management of the uCPE resources, VNFs, service chaining and all embedded functions.

Following diagram (Figure 4) shows how the OneOS6-LIM functions integrate into the protocol stack of an NFV implementation.

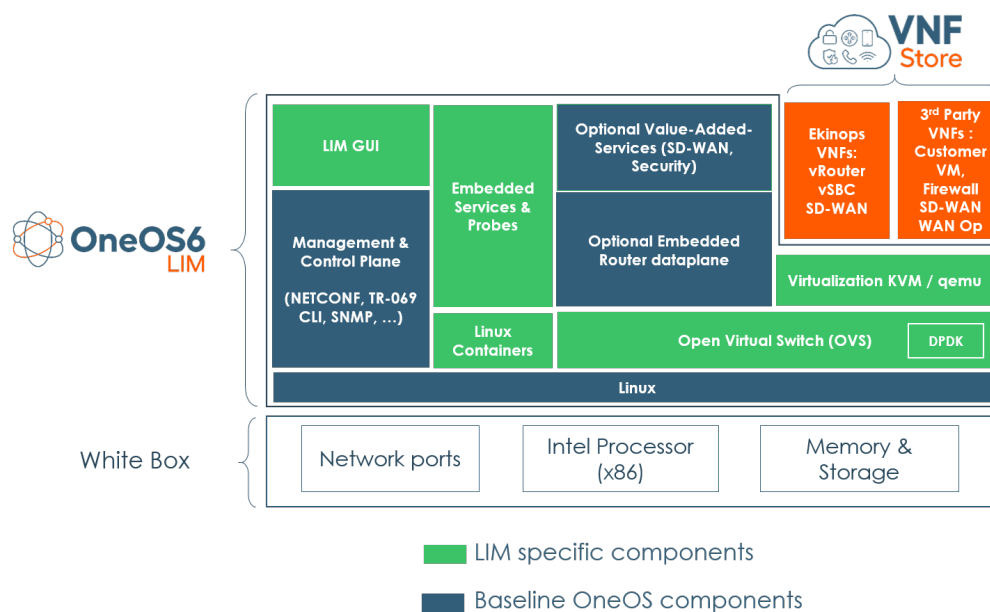


Figure 4 - Architecture

OneOS6-LIM extended functionalities

As depicted in the diagram (Figure 5), OneOS6-LIM also includes functionalities that go beyond those of a traditional hypervisor. These additional functionalities include:

- Embedded re-usable, pre-defined, common container-functions such as NAT, DHCP Server, Network Probes.
- The full, license based, embedded ONEe600 enterprise router, including advanced security and SD-WAN capabilities. This embedded router offers up to 10 Gbps wire-speed connectivity.

OneOS6-LIM acceleration support

In order to guarantee the maximum network performance, OneOS6-LIM supports the following acceleration techniques:

- DataPlane Development Kit (DPDK):
 - Zero-copy API for packet processing
 - DPDK for service chaining, DPDK for VNFs & routing
- Received-Side Scaling (RSS):
 - Automatic packet classification in queues
 - Packet processing parallelization
- Single root I/O virtualization (SR-IOV):
 - Share an Ethernet controller between VMs
 - Transform an Ethernet controller into a mini-Ethernet switch (hardware-assisted service chaining)
- Peripheral component interconnect - Passthrough (PCI-PT)
- Direct VM access to Ethernet controllers

OneOS6-LIM GUI

OneOS6-LIM provides a powerful front-end for the configuration and troubleshooting of VNF service chains. Using a Web GUI interface, it enables the setup of a complete service chain using drag and drop for physical interfaces, VNFs and debugging points. Once tested and debugged the topology of the tested service chain (or network service) as well as the VNFs can be exported and deployed on an operator scale network.

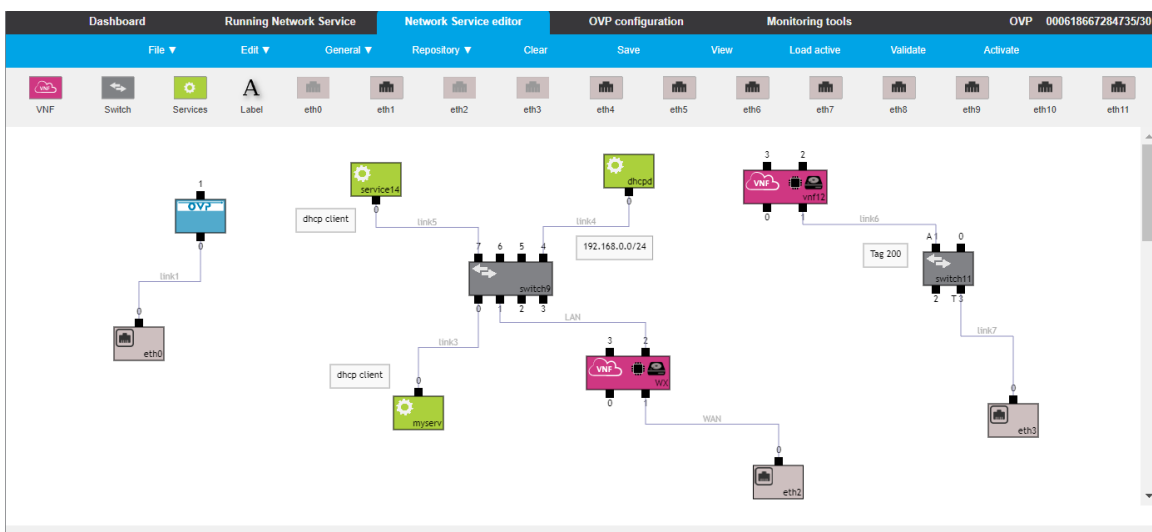


Figure 5 - OneOS6-LIM GUI

The chaining of VNFs can be done using L2 (tagged or untagged) or L3 connections and there is no limitation on the virtual topology.

An example of a service chain realized by the GUI on the OVP-LIM can be seen in the diagram (Figure 6) displaying a service chain of 3 VNFs connected to each other. The service runs between Ethernet ports Eth0 and Eth1. The internal management network (blue box) is on top, with the management interfaces connected together on a virtual switch. This network can be separately managed and secured.

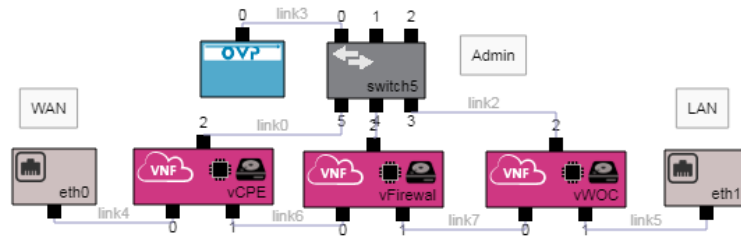


Figure 6 - Service chaining with several VNFs

Another example of a service chain can be seen in diagram (Figure 7) with the data running through a WAN optimizer (satellite connection) and a vRouter. In addition to the VNFs, there is also a file server and an HTTP server running in the same environment. This shows clearly that network functions (VNFs) can be mixed with IT applications (virtual servers).

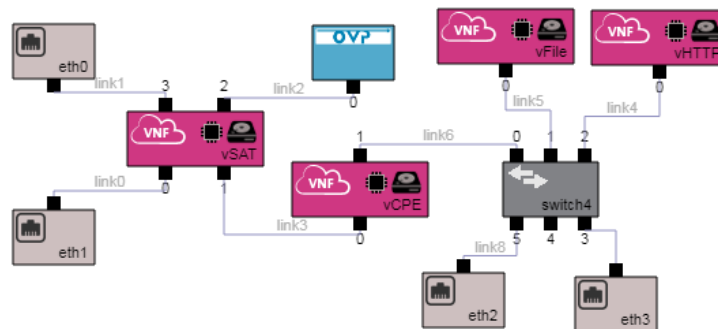


Figure 7 - Service of combined network and IT services

Compose VNF Support

The OneOS6-LIM middleware provides an open virtualization environment for Ekinops and third party VNFs.

OneOS6-LIM as hypervisor

VNFS proposed by Ekinops are:

- **ONEv600** is an enterprise full-featured router. In addition, the SD-WAN Xpress license enables the creation of application-aware hybrid WAN services. The ONEv600 technology provides SMB and enterprise customers with an extensive range of carrier-grade switching and routing functions and enables service providers and large network providers to deploy services within an NFV environment. This router is available as a separate VNF, or it can be activated as the embedded ONEe600 router, in case OneOS6-LIM is present as an hypervisor.
- **ONEvSBC** is an enterprise Session Border Controller (SBC). The ONEvSBC VNF enables to overcome the challenges inherent in routing SIP-based calls between network and customer premise equipment. It provides a simple and cost-effective solution for signal interworking, media interworking, address translation, network demarcation, Quality of Service (QoS) and security. The ONEvSBC provides SIP signaling resolution, SIP proxy and sSBC capabilities for SIP based PBXs and SIP phones, ensuring trouble free operation of SIP Centrex and SIP Trunking services to small and mid-sized offices.



Third party VNFs

Over 30 different VNFs from third parties have already been tested and deployed with Ekinops OneOS6-LIM. Among those tested-VNF suppliers, one can find: Cisco, Fortinet, Infovista, Palo Alto, Riverbed, Stormshield, VeloCloud and SilverPeak. A full list of validated VNFs is available as a separate document.

Thanks to the very open architecture of OneOS6-LIM, supporting new VNFs is a straightforward process.

In order to properly design a service, it is important to understand the performance of a third-party VNF as a function of the allocated resources (number of CPU cores and memory).

Another aspect is how a third-party VNF can be provisioned on a uCPE as to allow it to contact its VNF controller/orchestrator. Operational aspects of individual network functions (e.g. Firewall) will still be done from their own management platform. It is possible to define ISO disks within OneOS6-LIM that can be used to bootstrap the VNFs with initial configurations at the time of on-boarding.

Ekinops propose a range of virtualization-related professional services including “VNF Assessment Service”, which is designed to facilitate the on boarding of 3rd-party VNFs.

Compose services: NFV Management Framework

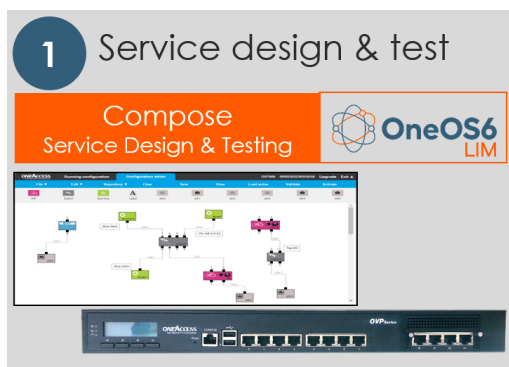
The OneOS6-LIM solution comes with a full set of open management interfaces, which makes it possible to integrate in third-party management environments.

- All functionality is modelled in YANG for seamless integration with service orchestrators using NETCONF/YANG for service automation
- Management APIs include SSH, CLI and TR-069 for gradual migration of management systems and operational support
- Powerful HTTPs Graphical User Interface enables to create and debug complex service chains in no time
- The solution supports Syslog and SNMP event logging and fault management

In addition to just offering management interfaces, Ekinops offers a turnkey management framework that consists of a design-time environment and an execution-time environment:

- The design-time environment allows defining, designing and creating Network Service Descriptors (templates). This solution is called **Design Studio**.
- The execution-time environment allows the zero-touch-provisioning and management of the services programmed in the design phase. This solution is called **OneManage**.

Following graph shows the process from initial service design up to mass-rollout:



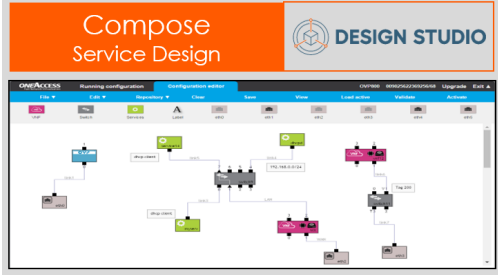
A service is designed using the GUI of OneOS6-LIM, running on a uCPE. This allows immediate testing of the service in a real environment.



Once tested, the configuration is exported from OneOS6-LIM, and imported into Design Studio.



2 Mass rollout preparation



The service design is further tuned, using Design Studio, in order to make the service design suitable for mass-rollout:

- Definition of the service variables, such as individual IP addresses, credentials, license keys, etc.
- Validation of the service for the different target hardwares (uCPE)



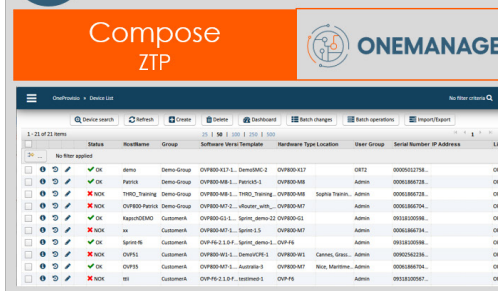
3 Network Service Design Template (NSD)



The output of Design-Studio is the Network Service Design Template (NSD). This template is a file containing an XML-based coding of the service, including its variables. It uses as a base the YANG modelling of the service.



4 Customization and ZTP



This template is imported in OneManage, which will use it for the provisioning.

OneManage will map the NSD (Network Service Descriptors) to the different end-users, and define the individual service variables for each customer. Once done, OneManage will do a full Zero-Touch-Provisioning of those customers.



ZTP uses bootstrap mechanism to automatically provision the uCPEs in the network.

Figure 8 - Process from initial service up to mass rollout

As a reference, following drawing shows the APIs of the different elements discussed in the remainder of this chapter.

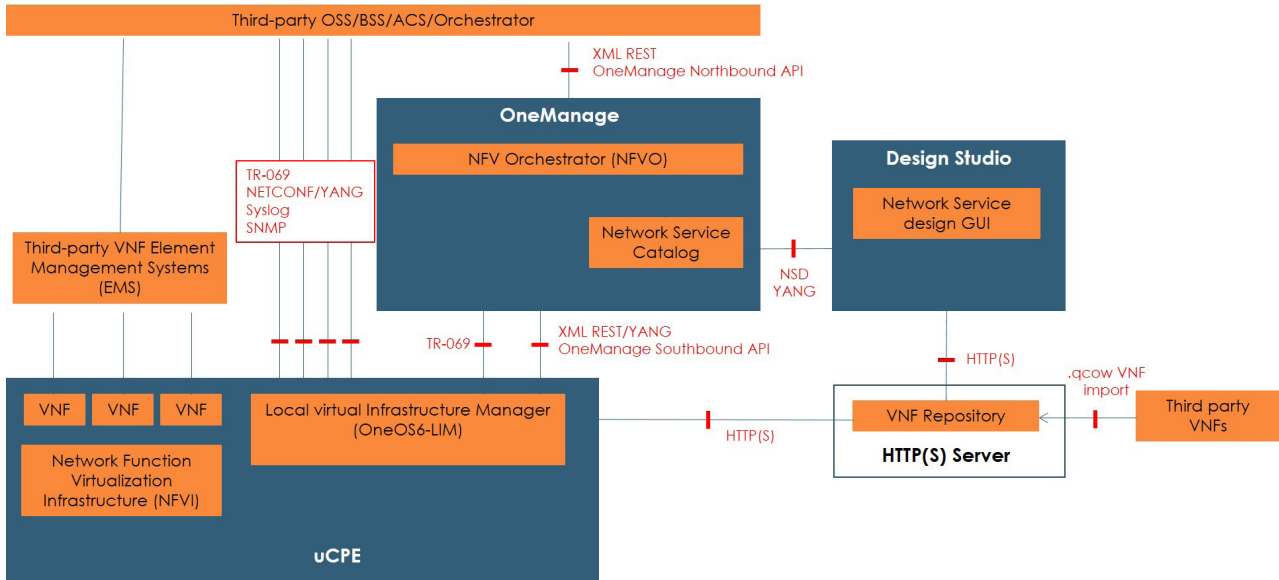


Figure 9 - Ekinops NFV Management Architecture



Design time environment: Design Studio

Marketing engineers, based on market analysis and customers' needs specify the high-level requirements for a new Network Service. Service designers, during the design phase, use the OneOS6-LIM web interface running on a uCPE to select the appropriate resources in order to implement and test the new defined service. Resources, either hardware or software, can be categorized in three main categories:

1. Infrastructure Resource (e.g. Compute, Storage, Devices)
2. Network Resource (network connectivity functions and network interface cards - NICs)
3. Application Resource (VNF disk images, Services and Probes)

Service designers combine these different resources to instantiate VNFs, and then chain VNFs, Services and Probes using virtual links to define a Network Forwarding Graph that provides the desired network service.

Once a service proves to be working, the sample design will be imported from OneOS6-LIM into Design Studio, offering a solid and tested service as a base for further tuning the service, and preparing the service for mass rollout.

Design Studio uses the same graphical user interface as OneOS6-LIM, so the tuning of the service is straightforward.

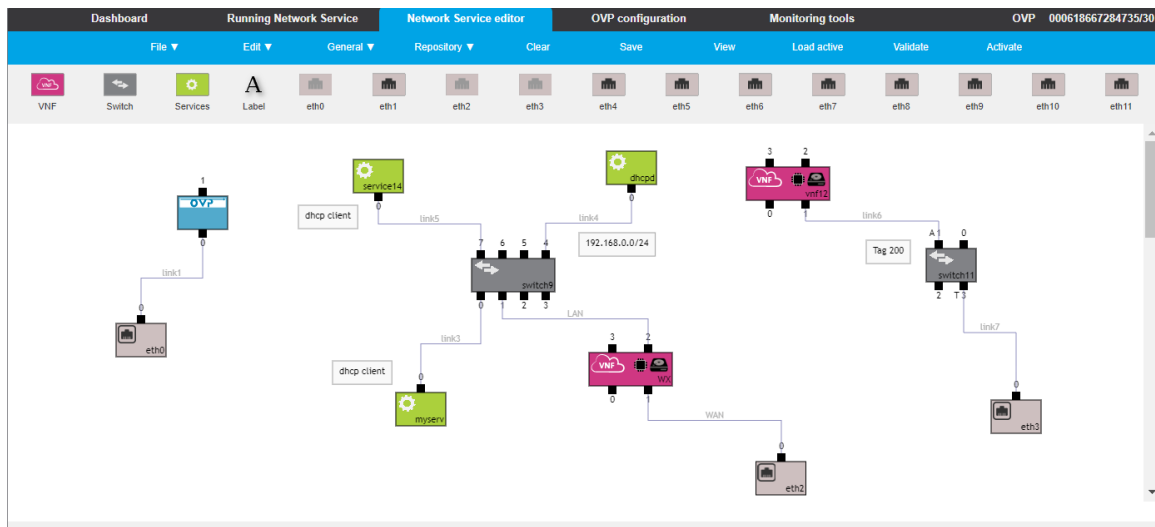


Figure 10 - Design Studio graphical design environment

Although the graphical design of a service in a OneOS6-LIM enabled uCPE and in Design Studio looks similar, the purpose of the service design is different.

- Within *OneOS6-LIM*, the service design serves as a service configuration tool for the specific uCPE on which it is running
- Within *Design Studio*, the service design is independent from the hardware (it typically runs as a VM on a central server), and is used to create service templates that will build the provisioning chain of the different uCPEs in the network.

Design Studio enables service designers to select the variables of a Network Service and declare them as “customizable”. Typical examples of such variables are IP addresses, user credentials, bandwidth parameters, etc. These parameters are defined and will be filled during the operation phase by OneManage.

In the example below (Figure 11), we can see the definition of the onboarding parameters for a VeloCloud VNF.

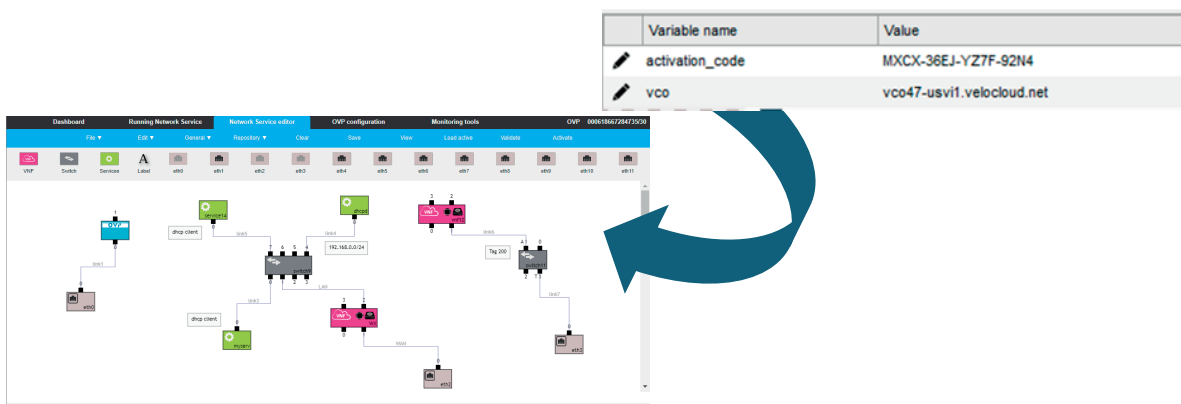


Figure 11 - Definition of variables in the NSD

The Network Service topology, including its configuration and variables is then released by Design Studio as a customizable Network Service template (called NSD for Network Service Descriptor). It is exported using NETCONF/YANG and published to the OneManage NSD catalogue.

The Network Service Descriptor (NSD)

The Network Service Descriptor is the top-level deployment template for a Network Service (NS).

A network service is made of:

- A set of VNFs, including their configuration and variables
- A set of instantiated embedded services offered by OneOS6-LIM, such as DHCP server, NAT or network probes (Embedded Services), including their configuration and variables
- A configuration of the embedded ONEe600 router, including its variables
- A chaining topology consolidating the different elements into a network service (LIM), as created by Design Studio, including its variables.

The variables included in the NSD package include their description, XPATH (location of the variable), type, range (for basic sanity check) and default values.

In addition, the NSD package contains:

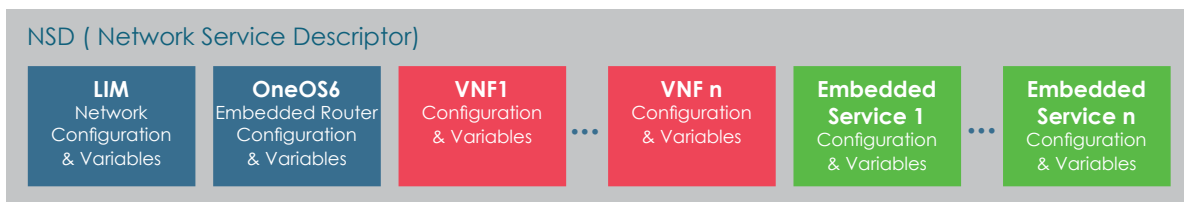


Figure 12 - Simplified representation of a NSD package

- A NSD meta-data including the NSD name, description, checksum, version, target uCPE hardware, version compatibility
- A picture of the service design, as made in the GUI of Design Studio



OneManage

OneManage is the Ekinops management suite automating CPEs', either physical or virtual, configuration and software image downloads. It also features a device monitoring and alarm framework. OneManage simplifies daily operations and increases productivity for lower operation costs.

OneManage hosts a catalog (list) of usable YANG-modelled Network Services Descriptors that have been previously designed and validated using the Ekinops Design Studio. A NSD is a deployment template for a network service in terms of VNFs and description of their connectivity through virtual links.

Service Operators choose from the Network Service Catalog the appropriate NSD to deploy on a given uCPE in order to meet their customers' requirements. Before deployment, the Service Operator may customize the NSD by changing the default value of some parameters (e.g. IP address). These customer-specific parameters can be provisioned either through the graphical interface of OneManage, or they can be retrieved from an overall Orchestrator OSS/BSS system (not proposed by Ekinops) through the northbound REST API of OneManage.

Zero-touch uCPE installation is enabled by an auto-configuration protocol based on a bootstrap mechanism. The system enables rapid uCPE configuration creation from NSD templates. uCPE are managed in groups where the network administrator can apply bulk changes for a whole group.

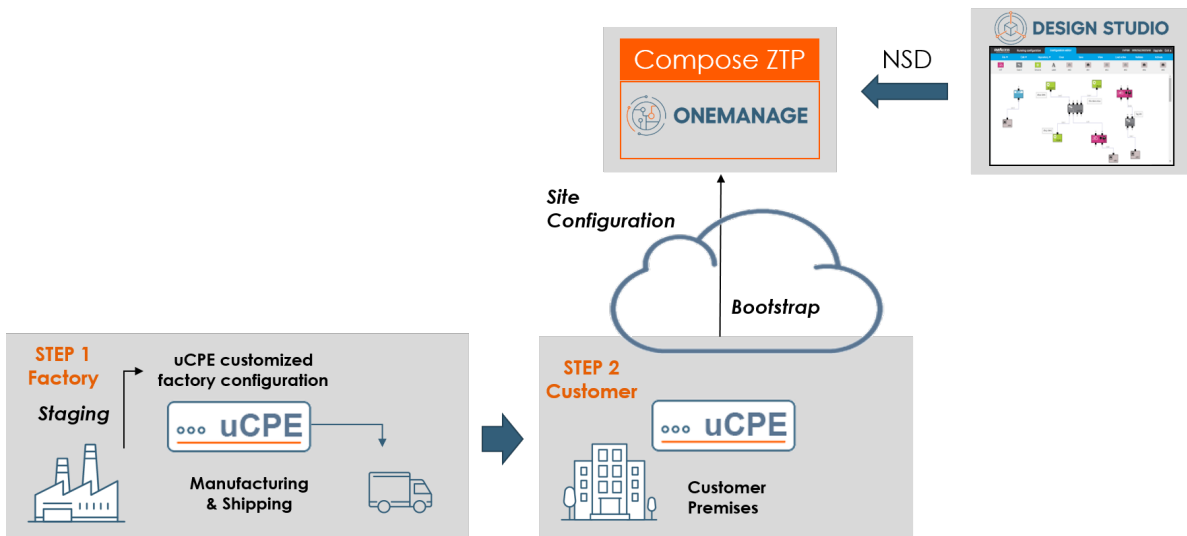


Figure 13 - OneManage ZTP process

OneManage fully manages the deployment of new end-users. The process can be triggered from the OneManage graphical user interface or from a third-party network manager equipment that uses the northbound REST API of OneManage. OneManage can also help to provision, administrate and manage VNFs such as Ekinops OnevSBC, Ekinops Onev600 (vRouter) or third-party VNFs.

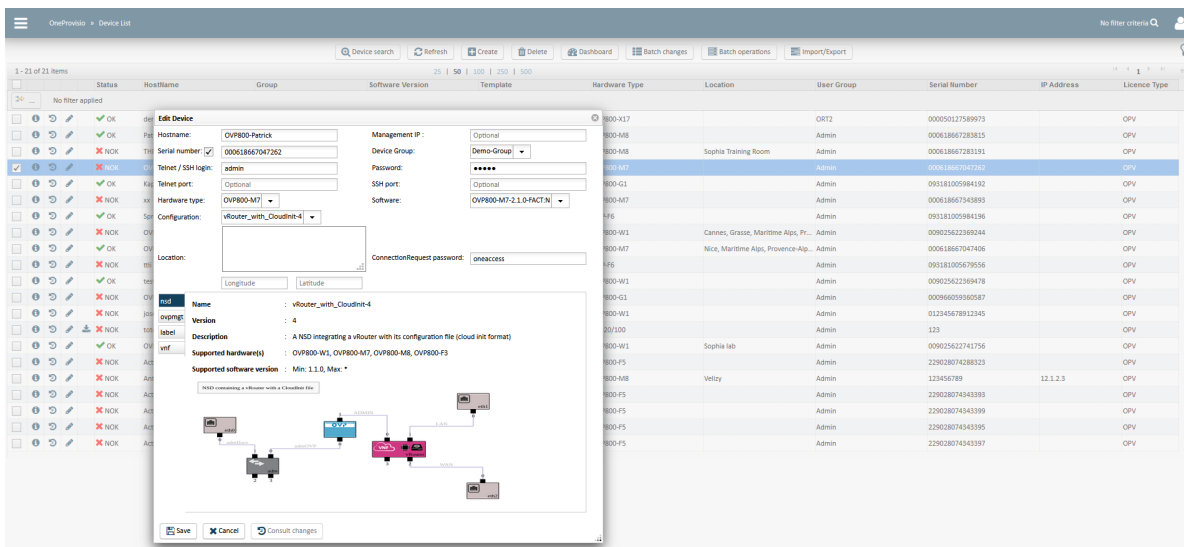


Figure 14 - Deployment of a new uCPE from the OneManage GUI

Conclusion

As described in this solution brief, Ekinops provides a complete turnkey virtualization solution with mature technology for fast time to market and quick ROI, pre-integrated with many VNF vendors. Based on open protocols and white boxes with no shades of grey, Ekinops virtualization solutions free Service providers from hardware and software lock-in.

About Ekinops

Ekinops is a leading provider of open and fully interoperable Layer 1, 2 and 3 solutions to service providers around the world. Our programmable and highly scalable solutions enable the fast, flexible and cost-effective deployment of new services for both high-speed, high-capacity optical transport networks and virtualization-enabled managed enterprise services

Our product portfolio consists of three highly complementary product and service sets: Ekinops360, OneAccess and Compose.

- Ekinops360 provides optical transport solutions for metro, regional and long-distance networks with WDM for high-capacity point-to-point, ring and optical mesh architectures, and OTN for improved bandwidth utilization and efficient multi-service aggregation.
- OneAccess offers a wide choice of physical and virtualized deployment options for Layer 2 and Layer 3 access network functions.
- Compose supports service providers in making their networks software-defined with a variety of software management tools and services, including the scalable SD-WAN Xpress.

As service providers embrace SDN and NFV deployment models, Ekinops enables future-proofed deployment today, enabling operators to seamlessly migrate to an open, virtualized delivery model at a time of their choosing.

A global organization, with operations in 4 continents; Ekinops (EKI) - a public company traded on the Euronext Paris exchange - is headquartered in Lannion, France, and Ekinops Corp., a wholly-owned subsidiary, is incorporated in the USA.

EKINOPS360
Dynamic Optical Transport

ONEACCESS
Fast Network Virtualization

 **COMPOSE**