

# Technical Product Description

## Virtual Service-Aware Policy Controller 1

### TECHNICAL PRODUCT DESCRIPTION

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## Abstract

The Technical Product Description describes the architecture, functions, configurations, interfaces, operation, and maintenance of the Ericsson Virtual Service-Aware Policy Controller (Virtual SAPC) 1.

The Virtual SAPC is the Telco Cloud ready version of the Ericsson SAPC. The Virtual SAPC is an already proven component in the Ericsson Virtual Evolved Packet Core (Virtual EPC) solution.



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# 1 Introduction

## 1.1 Document Purpose and Scope

The Technical Product Description document aims to provide a technical and functional description of the Ericsson Virtual Service-Aware Policy Controller (Virtual SAPC) 1. The Virtual SAPC provides the same functions as the physical SAPC, but architected for being deployed as a Virtualized Network Function (VNF) on a Network Function Virtualization Infrastructure (NFVI) .

This document includes description of the following areas:

- The cloud environment, surrounding the Virtual SAPC.
- The Virtual SAPC architecture.
- The Virtual SAPC management and orchestration.
- Characteristics and dimensioning.
- Requirements on the cloud system the Virtual SAPC imposes.

This document does not provide a description on the common functions shared by the SAPC and the Virtual SAPC. For such information, see Reference [1].

## 1.2 Revision Information

- |          |  |
|----------|--|
| <b>A</b> | This is the first release of this document.                                  |
| <b>B</b> | The document is updated with the content included in Virtual SAPC 1 Q4 2017. |





## 2 NFV Environment

The Virtual SAPC virtualization architecture allows the deployment of the Virtual SAPC in a NFV system. Therefore the Virtual SAPC becomes a VNF, which requires virtual resources (vCPU, memory, vNICs, storage) to a cloud infrastructure. The setup of the needed virtual resources is then managed through a Cloud Orchestration System and a NFVI. The NFVI is the responsible of assigning the virtual resources (vCPU, memory, etc.) the Virtual SAPC requires for its operation

This section describes supported NFV environments for Virtual SAPC deployment.

### 2.1 NFVI

#### 2.1.1 Ericsson Cloud Execution Environment (CEE)

The Virtual SAPC can be deployed on Ericsson CEE. Ericsson CEE provides a carrier grade NFVI cloud infrastructure and a Virtualized Infrastructure Manager (VIM). The CEE is based on OpenStack components and the Kernel-based Virtual Machine (KVM) hypervisor. The CEE supports Ericsson or third-party Commercial Off-The-Self (COTS) HW for compute, storage, and networking.

For further information, see Reference [7].

#### 2.1.2 VMware

The Virtual SAPC SW is delivered for being deployed on VMware vSphere 5.5, 6.0 or 6.5 NFVI. The VMware components required to deploy the Virtual SAPC are vCenter or vCloud Director.

The Virtual SAPC is a VMware NFV 2.0 Certified application.

#### 2.1.3 Third-Party OpenStack based NFVI

System integration with a third-party NFVI cloud infrastructure based on OpenStack is possible. The Virtual SAPC has no explicit direct interface toward the cloud infrastructure. However, the Virtual SAPC has dependencies to the following:

- The Virtual Machine (VM) environment exposed by the hypervisor (KVM).
- The infrastructure networking solution.
- The performance, characteristics, and robustness of the infrastructure.

The Virtual SAPC has been already verified with the OpenStack based HPE Helion.

For requirements on the cloud infrastructure, see Section 6.2 on page 19.

## 2.2 NFV Management and Orchestration System

### 2.2.1 Ericsson Cloud Manager (ECM)

ECM provides management and orchestration of virtual resources across multiple VIMs, and G-VNFM functionality for generic life cycle management of VNFs. ECM supports VNF descriptors in Open Virtualization Format (OVF) and Heat Orchestration Template (HOT).

Because of the Virtual SAPC supports OVF and HOT, ECM can be used for its management and orchestration.

For further information on ECM, see Reference [8].

### 2.2.2 Atlas

Atlas is a set of management tools included in CEE, that can be used as a simplified alternative to ECM. It is based on the OpenStack components Horizon dashboard and Heat orchestration.

Atlas supports VNF packages in OVF and HOT formats.

Because of the Virtual SAPC supports HOT, Atlas can be used for its management and orchestration.

For further information on Atlas, see Reference [7].

### 2.2.3 Third-Party Cloud Management System

System integration with a third-party cloud management system is possible.

The Virtual SAPC has no direct interface toward the cloud management system. However, the Virtual SAPC has dependencies to the following:

- The VM image and the VNF Descriptor supported by the cloud management system. For instance, the provided OVF package may be translated, if needed, to a different one (e.g. TOSCA).
- Procedures for lifecycle management: The Virtual SAPC is pre-integrated with Ericsson OSS-RC and Ericsson Network Manager (ENM). A third-party VNF Manager (VNFM) would require system integration.
- The policy requirements for the Virtual SAPC deployment: For instance, the Virtual SAPC requires anti-affinity rules (see Section 3.3.2 on page 9).

For requirements on the cloud management system, see Section 6.1 on page 19.





## 2.3 VNF Manager

The Virtual SAPC has the same northbound interfaces as the physical SAPC. Therefore Either OSS-RC or ENM may be used as the Element Manager (EM) for both the physical and the Virtual SAPC.

OSS-RC and ENM also provide S-VNFM functionality for specific life cycle management of Ericsson VNFs, including the Virtual SAPC.





## 3 Virtual SAPC Architecture

### 3.1 Virtualization Architecture

The Virtual SAPC virtualization architecture consists of several VMs taking different function roles.

- System Controllers (SC) VMs: 2 VMs implementing system controllers function. These VMs provide the north-bound access to the Virtual SAPC and the cluster membership and control.
- Traffic Processors (TP) VMs: “n” (at least 2, maximum 34) VMs for providing the Policy Server implementation. This VMs are also referred as Payload (PL) VMs.

**Note:** The maximum of 34 TP VMs limit is a testing limit in the Virtual SAPC 1 release.

Both the 2 SC VMs and the TP VMs configure the Virtual SAPC cluster. However, the SW delivery includes an additional and optional type of VM:

- Virtual Router (VR): 4 VMs providing the Virtual Routing Service (based on Vyatta VR). These VMs are optional. 2 of the VR VM are responsible for Operation and Maintenance (OAM) tasks, and the other 2 for addressing the control plane traffic the Virtual SAPC manages.

**Note:** The Virtual SAPC recommended configuration is without VR VMs.

Figure 1 displays the described the Virtual SAPC virtualization architecture.

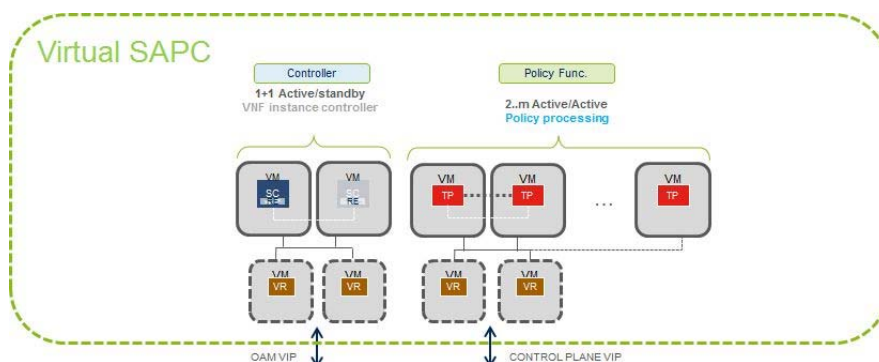


Figure 1 The Virtual SAPC virtualization architecture

### 3.2 Deployment Types

The Virtual SAPC provides validated deployment types. The validated deployment types specify VM sizes, number of VMs, and distribution of VMs over the available compute hosts of the Virtual SAPC.



- Multi-host Virtual SAPC: This deployment targets scalability and high capacity, with full SW and HW redundancy.
- Single-host Virtual SAPC This deployment targets small footprint with limited capacity. The deployment has small VM sizes, all collocated on one compute host . It supports full SW redundancy including VM redundancy. The deployment does not support HW redundancy. However, network level redundancy can be achieved through a pair of the Virtual SAPC instances configured as 1+1 IP Geographical Redundant.

**Note:** The VM sizes and numbers in Table 1 and Table 2 have been validated. However, other VM sizes and numbers can be used, depending on the dimensioning needs.

Table 1 The Virtual SAPC minimum size configuration

VM Role	Number of VMs	vCPU	RAM Memory (GB)	Hard Disk (GB)
SC	2	2	6	40
TP	2-34	2	10	0
VR (optional)	4	2	1	4

Table 2 The Virtual SAPC normal-size configuration

VM Role	Number of VMs	vCPU	RAM Memory (GB)	Hard Disk (GB)
SC	2	4	6	60
TP	2-34	16	20	0
VR (optional)	4	2	1	4

The Virtual SAPC is also part of Ericsson Virtual EPC offerings. Virtual EPC deployments are not described in this document.

## 3.3 Resilience and Redundancy

All the Virtual SAPC software components are supervised by the Virtual SAPC middleware. Recovery actions for SW components are triggered by the Virtual SAPC middleware when needed. Supervision and redundancy handling does not depend on specific HW failure notifications from the virtualization and infrastructure layers. This means that mechanisms such as session resilience work the same way as they do in the SAPC Physical Node Function (PNF).

### 3.3.1 VM Redundancy

The VM redundancy models are as follows:



Table 3 VM redundancy models

VM Role	Redundancy Model
SC	1+1 active-standby
TP	1+1 active-active
VR OAM (optional)	1+1 active standby
VR Traffic (optional)	1+1 active standby

### 3.3.2 Anti-affinity rules

High availability implementation requires the definition of anti-affinity rules. These rules must be considered for any Multi-host Virtual SAPC deployment (as it was defined in Section 3.2 on page 7).

- The 2 SC must not be collocated in the same physical host.
- Each TP must be collocated in a different physical host.
- The 2 optional VR for OAM must not be collocated in the same physical host.
- The 2 optional VR for Traffic must not be collocated in the same physical host.

In case the anti-affinity rules are not implemented, the consequences are the following:

- The Virtual SAPC reboots in case of physical host failure: This happens if either the 2 SC are down for more than 15 minutes, or at least 2 TP VM are collocated in the failing physical host.
- If the optional VR VM are used: Lack of external connectivity towards the Virtual SAPC because of either the 2 VR for OAM, or the 2 VR for Traffic are in the failing physical host.

### 3.3.3 Physical Link Redundancy

The Virtual SAPC is not aware of the cloud network topology. Therefore, it does not perform failover between two virtual NICs (vNICs) on the same VM. It is the responsibility of the cloud infrastructure to provide physical link redundancy.

### 3.3.4 Storage Redundancy

The Virtual SAPC has redundant storage on the SC VMs.



## 3.4 Networking

### 3.4.1 Internal networking

The detailed description of the Virtual SAPC internal networking is available in the SAPC VNF Network Configuration Guide (Reference [6]).

### 3.4.2 External networking

The detailed description of the Virtual SAPC external networking is available in the SAPC VNF Network Configuration Guide (Reference [6]).

### 3.4.3 Characteristics per Virtual Network

The following table specifies the purpose and characteristics of the different Virtual Networks (VN) used by the Virtual SAPC.

Table 4 Virtual Network Characteristics

	Internal VNs	External OAM VN	External Traffic VNs
<b>Purpose of VNs</b>	The Virtual SAPC VM-to-VM.	OAM.	The Virtual SAPC external traffic.
<b>Possibility to share the VN with other VNF instances</b>	No.	No.	No.
<b>Externally connected to networks outside the cloud</b>	No.	Yes.	Yes.
<b>vNIC IP address assignment</b>	SC VM will do IP address assignments using the internal DHCP.	Configured through cloud injected file in the Virtual SAPC.	Configured through cloud injected file in the Virtual SAPC.
<b>Supported IP versions</b>	IPv4.  IPv6 (by System Integration adaptations).	IPv4.  IPv6 (by System Integration adaptations).	IPv4.)  IPv6 (by System Integration adaptations).
<b>IP MTU size</b>	Manually configured Default: 1500 bytes.	Manually configured Default: 1500 bytes.	Manually configured Default: 1500 bytes.



<b>IP routing</b>	Handled internally by the Virtual SAPC.	Through static routes via the Virtual SAPC High Availability Front Ends (recommended).  Through VR OAM VM (alternative).	Through static routes via the Virtual SAPC High Availability Front Ends (recommended).  Through VR Traffic VM (alternative).
<b>vNIC MAC address assignment</b>	OpenStack deployments: Value defined by the Virtual SAPC (no option to configure it).  VMware deployments: Dynamic MAC address assignment by the NFVI.	OpenStack deployments: Value defined by the Virtual SAPC (no option to configure it).  VMware deployments: Dynamic MAC address assignment by the NFVI.	OpenStack deployments: Value defined by the Virtual SAPC (no option to configure it).  VMware deployments: Dynamic MAC address assignment by the NFVI.
<b>Support for application VLAN tagging (trunk vNIC)</b>	No.	Not provided by default.	Not provided by default.

## 3.5 Storage

The Virtual SAPC storage is on the SC VM root disk, thus the VM disk image, which is used to boot the VM. The storage includes SW data, configuration data, backup information, log files and performance monitoring files.

The optional VR VMs also includes storage. The storage includes just the Vyatta VR SW image.

The TP VMs use only the local VM disk image for booting. They do not write to the local disk, but manage their data (both provisioning and dynamic) in memory.

The Virtual SAPC storage capacity can be modified at deployment time, but cannot be changed during operation. For information about storage requirements on the cloud infrastructure, see Section 6.2 on page 19.

The cloud infrastructure is responsible for implementing the storage back end, which is transparent to the Virtual SAPC.



## 3.6 Security

The Virtual SAPC is delivered with default hardening. For more information about hardening and security of the Virtual SAPC, see Reference [2].

The security of the Virtual SAPC strongly depends on the underlying security of the cloud infrastructure.





## 4 Management and Orchestration

The main OAM functions (Configuration Management, Data Provisioning, Fault Management, Performance Management, log management, backup & restore, troubleshooting and upgrade) are the same ones in the SAPC PNF and in the Virtual SAPC. However, there are some differences in other OAM functions. They are described in the following sections.

### 4.1 Deployment

There are two methods to deploy the Virtual SAPC.

- An OVF package is created using a tool (script) and the Virtual SAPC SW images from the delivered SW. The OVF package is then deployed in the cloud manager. Different OVF packages are provided for ECM or VMware vCloud Director/vSphere/vCenter.
- OpenStack Orchestration (Heat): A HOT is created using a tool (script) and the Virtual SAPC SW images from the delivered SW. The Virtual SAPC SW images are uploaded to OpenStack (Glance), and the HOT is then applied in OpenStack.

The Virtual SAPC provides HOT VNF Lifecycle Manager (VNF-LCM) workflows for onboarding and VNF deployment.

When the cloud system boots the VMs, the Virtual SAPC automatically starts to run on the SW that is pre-installed on the SW images.

Configuration information can be injected into the VNF at deployment time by cloud injection.

Detailed information is available in Reference [3] and Reference [4].

### 4.2 HW Management

The Virtual SAPC is a NFV-ready SW, so it has no direct coupling to the physical HW it is deployed on. Therefore the Virtual SAPC cannot provide any status, alarms, or counters related to the physical HW. The cloud infrastructure needs to provide this information for the operator.

However, the VMs in the Virtual SAPC are considered as equipment. So the VMs can be monitored and can for example, be restarted, locked, and unlocked.



## 4.3 Scaling

The Virtual SAPC can be scaled-out or scaling-in dynamically due to application capacity needs. The scaling out consists of adding additional TP VMs to the Virtual SAPC. The scaling-in means to remove TP VMs from the Virtual SAPC. The maximum and minimum sizes for scaling-out/in is indicated in Section 3.1 on page 7.

**Note:** SC VMs and the optional VR VMs does not scale.

After scaling-out or scaling-in, the traffic is automatically rebalanced across all the TP VMs in seconds.

The Virtual SAPC provides HOT VNF-LCM workflows for manual and automatic scaling-out.

Scaling-up (increasing dynamically the VM size) and scaling-down (decreasing dynamically the VM size) is not supported.

## 4.4 Decommissioning

The Virtual SAPC can be easily decommissioned from operation in just seconds. This is done via VNF de-instantiation through the cloud management system.

The Virtual SAPC provides HOT VNF-LCM workflows for the decommissioning.

## 4.5 VMware Tools

The Virtual SAPC includes Open VM Tools (OVT) in the guest OS. OVT is an open source implementation of VMware Tools. It consists of virtualization utilities that improve the functionality and management of VMs within a VMware environment.

Table 5 describes how the Virtual SAPC supports OVT.

Table 5 OVT Support in the Virtual SAPC

OVT Feature	Support in the Virtual SAPC
Synchronize the guest OS clock with the virtual infrastructure	Disabled. SAPC synchronizes the clock with an external NTP server
Enable the virtual infrastructure to perform graceful shutdown of the VM	Enabled
Enable the virtual infrastructure to quiesce the file system of the VM before taking a VM snapshot	Disabled
Provide a heartbeat from the guest to the virtual infrastructure to support vSphere High Availability	Enabled



Publish information about the guest OS to the virtual infrastructure, including resource use and networking information	Enabled
Provide a secure and authenticated mechanism to perform various operations within the guest OS from the virtual infrastructure	Disabled. The Virtual SAPC OAM interfaces provide accountability logging and enforcement of role-based access rights on VNF level, and must therefore be used
Customize the guest OS when deploying a new VM	Disabled
Improve the interaction with the guest desktop environment	Disabled. The Virtual SAPC does not provide a desktop environment





## 5 Characteristics and Dimensioning

Ericsson has a set of tools for capacity planning, including dimensioning guidelines and a dimensioning calculation tool. The tools are available for Ericsson personnel who can assist the customer with capacity planning scenarios. Inputs for the dimensioning are cloud system and HW characteristics, control plane and user plane traffic models, and the used the Virtual SAPC feature set.

The dimensioning calculation tool has reference models of the cloud system and hardware. Deviations from the reference model and the cloud system requirements can have an impact on the Virtual SAPC characteristics and lead to degraded performance. The requirements are described in Section 6 on page 19. Each deviation compared to the stated requirements can require more HW resources than the reference model indicates, or can require system integration work to fill any performance gaps.

For more information about characteristics and dimensioning, see Reference [5].





## 6 Requirements on the Cloud System

This section describes the requirements on the cloud system components.

Deviations from the requirements can have an impact on the Virtual SAPC characteristics and can risk both performance and robustness. Deviation from the requirements can require system integration to fill any design gaps.

### 6.1 Cloud Management System Requirements

The Virtual SAPC has the following requirements on the cloud management system:

- Support VM anti-affinity policies or a solution to control the VM placement on the physical compute hosts.
- Support pre-defining of the vNIC MAC address.
- Optionally support OpenStack configuration drive using ISO 9660 file system for injection of configuration data.
- Only cloud management system users with appropriate authority should have access to the Virtual SAPC and its virtual resources.

### 6.2 Cloud Infrastructure Requirements

#### 6.2.1 Compute

- Cloud service model: IaaS.
- Deployment unit: VM.
- Hypervisors: KVM or VMware ESXi 5.5/6.0.
- The cloud infrastructure must not overcommit CPU, memory, or disk resources.

For optimal performance of the Virtual SAPC, the recommendation is to enable the hyper-threading.

#### 6.2.2 Networking

- VM vNIC Ethernet adapter types: KVM: VirtIO; VMware ESXi: vmxnet3.
- Minimum number of vNICs per VM: 3 per VR VM (optional); 3 per TP VM; 3 for SC1 VM and 3 for SC2 VM.



- Number of vNICs for the smallest the Virtual SAPC cluster configuration: 12 (24 with VR VM).
- L2 virtual networks must be supported.
- The cloud infrastructure must provide physical Ethernet link redundancy for each vNIC.
- Recommended maximum link failover time in the cloud infrastructure: 0.5 seconds.

### 6.2.3 Storage

- VM virtual disk controller: KVM: VirtIO; VMware ESXi: IDE.
- If centralized storage is used, it must provide High Availability in all aspects including the SAN network.
- If local storage is used, see Section 6.3 on page 20 for detailed storage requirements.

## 6.3 Compute Host HW Requirement

This section specifies the compute host HW requirements for the Virtual SAPC.

- CPU architecture: x86\_64.
- Minimum number of logical CPUs (hyper-threads) for VM use: 2.
- Minimum amount of RAM for VM use: 1 GB per VR VM (optional VM), 6 GB per SC VM, 10 GB per TP VM.
- Minimum disk space for VM use: 4 GB per VR VM (optional VM), 40 GB per SC VM, 0 GB per TP VM.

One the Virtual SAPC instance must be deployed on compute hosts within the same site. All the compute hosts should be connected to the same switch, or at least with minimal number of network hops between the compute hosts.

## 6.4 Additional considerations

Being a control plane application, the Virtual SAPC is not a performance critical telecommunications application. Then it does not require Single Root Input/Output Virtualization (SR-IOV), Data Plane Development Kit (DPDK) or similar utilities.

The Virtual SAPC is not Non-Uniform Memory Access (NUMA) aware. Therefore it is not recommended to define VMs whose size may imply the VM is deployed in more than one NUMA cell.





# Glossary

**CEE**  
Cloud Execution Environment

**COTS**  
Commercial Off-The-Self

**DHCP**  
Dynamic Host Configuration Protocol

**DPDK**  
Data Plane Development Kit

**ECM**  
Ericsson Cloud Manager

**EM**  
Element Manager

**ENM**  
Ericsson Network Manager

**EPC**  
Evolved Packet Core

**G-VNFM**  
Generic VNFM

**HOT**  
Heat Orchestration Template

**HW**  
Hardware

**IP**  
Internet Protocol

**KVM**  
Kernel-based Virtual Machine

**MAC**  
Media Access Control

**MTU**  
Maximum Transmission Unit

**NFV**  
Network Functions Virtualization

**NFVI**  
NFV Infrastructure

**NIC**  
Network Interface Card

**NUMA**  
Non-Uniform Memory Access

**OAM**  
Operation and Maintenance

**OSS**  
Operations Support Systems

**OVF**  
Open Virtualization Format

**OVT**  
Open VM Tools

**PL**  
Payload

**PNF**  
Physical Node Function

**SC**  
System Controller

**SR-IOV**  
Single Root Input/Output Virtualization

**S-VNFM**  
Specific VNFM

**SW**  
Software

**TP**  
Traffic Processor

**vCPU**  
Virtual Central Processing Unit

**VIM**  
Virtualized Infrastructure Manager



**Virtual SAPC**

Ericsson Virtual Service-Aware Policy Controller

**VLAN**

Virtual Local Area Network

**VM**

Virtual Machine

**VN**

Virtual Networks

**VNF**

Virtualized Network Function

**VNF-LCM**

(VNF Lifecycle Manager)

**VNFM**

VNF Manager

**vNIC**

Virtual Network Interface Card

**VR**

Virtual Router



## Reference List

### Ericsson Documents

- [1] Technical Product Description: Service-Aware Policy Controller 1, 1/221 02-FGC 101 3390/1
- [2] Security Management Guide, Service-Aware Policy Controller, 29/1553-CSH 109 215/7
- [3] SAPC VNF Deployment Instruction for CEE , 3/1531-CSH 109 215/7
- [4] SAPC VNF Deployment Instruction for VMware, 4/1531-CSH 109 215/7
- [5] SAPC 1 Network Impact Report, 109 48-FGC 101 3390/1
- [6] SAPC VNF Network Configuration Guide, 20/1553-CSH 109 215/7
- [7] CEE Technical Description, 221 02-FGC 101 3270 Uen
- [8] Product Overview. Ericsson Cloud Manager, 1/1550-CSH 109 232 Uen E