THE JOURNEY TO PACKET CORE VIRTUALIZATION

EVOLVING THE PACKET CORE TO AN NFV/SDN ARCHITECTURE

TECHNOLOGY WHITE PAPER

In their efforts to become more competitive, mobile network operators (MNOs) have begun their journey to packet core virtualization. The first step is to identify the key Network Functions Virtualization (NFV) requirements of mobile packet core evolution to a virtualized Evolved Packet Core (vEPC) architecture.

After discussion with many MNOs to understand their needs, economic drivers and concerns, Alcatel-Lucent has identified the key requirements for mobile core NFV transformation. As a strategic partner, Alcatel-Lucent offers MNOs multiple evolution paths to evolve their mobile core network to a vEPC according to their business goals and timelines.

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MARKET TRENDS

The journey to packet core virtualization in mobile networks has begun. Mobile network operators (MNOs) are evolving their voice and data networks to Network Functions Virtualization (NFV) and software-defined networking (SDN) in an effort to become more competitive by:

- Reducing the cost and improving the operational efficiencies of delivering services
- Becoming more agile and faster in delivering new services
- Increasing the return on investment (ROI) from their 2G/3G/LTE assets

This movement has led to the formation of an ETSI Interest Study Group, Network Functions Virtualization[1], to bring cloud computing networking technology and innovation into wireline and wireless networks.

By moving the functions of the network from dedicated, proprietary hardware platforms to high-volume, general-purpose computing platforms and open-source software, MNOs they can reduce network costs while improving the speed to market for updates and changes to the network. At the same time, they can increase innovation and create new services through a more open ecosystem.

MNOs are evaluating NFV, with IP Multimedia Subsystem (IMS) and Evolved Packet Core (EPC) as the first applications they are trialing and planning to commercialize. And Alcatel-Lucent is working with many MNOs to understand their network virtualization requirements, cloud evolution plans and the underlying economic drivers for this change. This collaboration has also led to the co-development of several packet core evolution options to a virtualized EPC (vEPC) that enable MNOs to reach their business goals while continuing to support their existing wireless network infrastructure.

To succeed in this significant network transformation, MNOs need to partner with vendors that have broad experience in mobile packet core, carrier cloud/NFV and SDN. As a market leader in long rerm evolution (LTE) EPC, NFV and SDN, Alcatel-Lucent understands what it takes to transform the core network to a vEPC.

WHY NFV FOR THE MOBILE CORE – AND WHY NOW?

With increasing consumption of rich multimedia services, the need to develop an engaging customer experience, and the emergence of new services such as voice over LTE (VoLTE) and M2M, MNOs are seeking new solutions to address the ongoing business goals of:

- More efficiently handling unpredictable demand at as low a cost as possible without sacrificing customer experience
- Creating a network that supports affordable and fast service innovation and expansion
- Lowering the business/ROI hurdle for supporting existing services while introducing new ones

These goals led to the examination of different technologies that could better address the dynamic and unpredictable nature of delivering mobile broadband services for consumers and businesses. The cloud computing and services industry was a logical choice to see if MNO business goals could be better served by using this technology.

1 European Telecommunication Standards Institute, ETSI GS NFV 010 v0.1.5 (2013-07): *Network Functions Virtualisation. End-to-End Architecture.* July 2013

BENEFITS OF MOVING THE MOBILE CORE TO NFV

The benefits of NFV to MNOs as outlined in the ETSI NFV white paper[2] are well documented and generally accepted. However, the benefits identified will vary depending on which network functions are being virtualized.

For the mobile core, the expected benefits of virtualization are:

- Improved operational efficiency: A vEPC running on a standard NFV infrastructure will deliver some operational efficiencies through reduced network costs and simplified operations. But the real operational efficiency gains will come in the automation of the vEPC with cloud orchestration and SDN.
- Optimized network configuration and/or topology through performance monitoring: The monitoring of the vEPC network function thresholds by the element management system (EMS) and the cloud orchestration management system will provide the MNO with synthesized data to quickly optimize the network configuration and topology through templates and recipes in a few simple steps. Automated virtual machine (VM) connectivity and optimization will be provided through an SDN employing policy-based routing.
- Support for multi-tenancy: Multiple vEPC network functions can be configured on the same NFV infrastructure. This functionality also provides MNOs with the flexibility to more closely match core capacity with service demands.
- Faster time-to-market for new services: Cloud automation in a vEPC will speed delivery of new services. With a broader ecosystem and the ability to expose the network resources, MNOs will be able to offer more services, faster.
- Targeted service introduction based on geography or customer location: The targeted service introduction can scale quickly to meet a spike in demand. With automation, the vEPC can quickly scale up or down to meet service demands.

REQUIREMENTS IN MOVING THE MOBILE CORE TO NFV

While cloud computing and SDN are not new technologies, the concepts of NFV, cloud architectures and SDN in a mobile network are relatively new. In transforming the existing packet core to a vEPC there will be a number of technical requirements to meet.

Alcatel-Lucent's discussions with MNOs have identified some of the key requirements in making this network transformation to NFV:

- Meet or exceed today's stringent requirements for mobile broadband service availability and real-time performance while operating transparently across a mix of traditional and cloud-based mobile infrastructure that will remain in place for a long time
- Operate in an open environment, leveraging industry-standard APIs to interact with independent compute, storage and networking hardware, hypervisors and cloud orchestration systems
- Deliver on the promise of event-driven, flexible service/capacity instantiation and scaling
- Provide clear linkage and visibility into the operational domain to monitor, maintain and evolve mobile network infrastructure

2 European Telecommunication Standards Institute, Network Functions Virtualization – Update White Paper Issue 1. October 2013

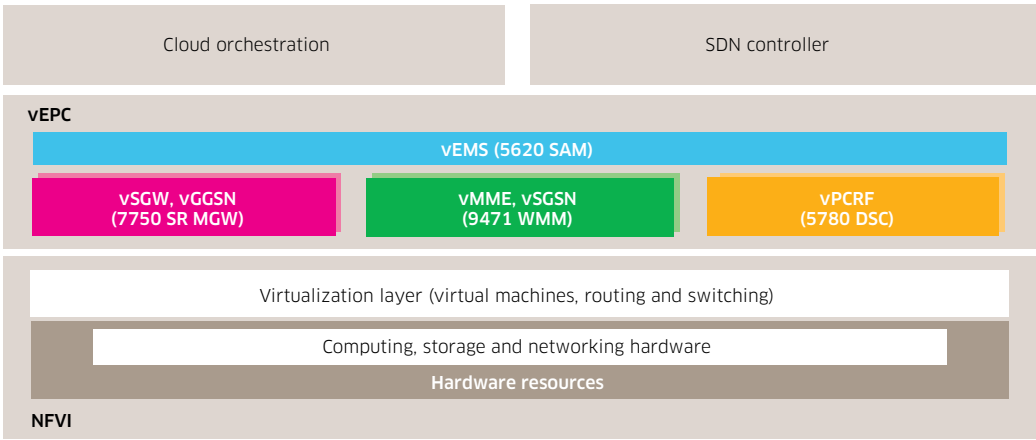
ALCATEL-LUCENT VIRTUALIZED EVOLVED PACKET CORE

The Alcatel-Lucent virtualized Evolved Packet Core (vEPC) is a set of software products and licenses that virtualizes all of the network functions of the mobile packet core, as described in the following sections.

The vEPC is a new deployment option that is offered for the Alcatel-Lucent IP Mobile Core solution. It uses the same field-proven application software from each of the products in the solution and, identical to the IP Mobile Core, it supports converged 2G/3G/LTE and Wi-Fi® networks. This functionality gives MNOs the ability to seamlessly interoperate the IP Mobile Core vEPC and the physical packet core network functions. The Alcatel-Lucent vEPC will operate on any industry-standard, open NFV infrastructure, as shown in Figure 1.

For more information on Alcatel-Lucent's IP Mobile Core go to: **Alcatel-Lucent IP Mobile Core**.

Figure 1. Components of the Alcatel-Lucent vEPC offer



Virtualized network functions

Packet processing and service delivery

The Alcatel-Lucent 7750 Service Router as a Mobile Gateway provides virtualized LTE Serving Gateway (vSGW), virtualized Packet Data Network Gateway (vPGW) and virtualized Gateway GPRS Support Node (vGGSN) network functions. It is based on the industry-leading 7750 SR and its subscriber-, service- and application-aware IP and mobile gateway Service Router Operating System (SR-OS).

Signaling and mobility management

The Alcatel-Lucent 9471 Wireless Mobility Manager (WMM) software is field-proven and design-optimized to support the increasing signaling loads on the packet core. It supports the virtualized Mobility Management Entity (vMME) and virtualized Serving GPRS Support Node (vSGSN) functions.

Policy and charging

The Alcatel-Lucent 5780 Dynamic Services Controller (DSC) is a multifunctional, software product that includes the Policy and Charging Rules Function (PCRF), the Diameter Control Point (DCP), the Access Network Discovery Selection Function (ANDSF) and the Smart Plan Builder. 5780 DSC virtualizes these functions, including the Policy Charging and Rules Function (vPCRF).

Element and network management

The Alcatel-Lucent 5620 Service Aware Manager (SAM) is an integrated element/network management system that provides service-level visibility, simplified operations and enhanced IP troubleshooting capabilities across the entire wireless network, including the packet core, mobile backhaul and LTE Radio Access Network (RAN). The 5620 SAM itself can be virtualized (vEMS) and provides a common interface to manage both virtualized and physical network functions.

vEPC architecture and design approach

Alcatel-Lucent expects that most MNOs will evolve to a fully virtualized packet core network. In the interim, there will be packet core networks with a mix of virtualized and physical network functions that must interoperate seamlessly with the existing RAN, other packet data and mobile networks and existing Operations Support Systems/ Business Support Systems (OSSs/BSSs).

The Alcatel-Lucent vEPC architecture and design approach supports this situation while ensuring:

- The vEPC network functions have a cloud-optimized architecture that takes full advantage of NFV/SDN architectures
- Scalability, to provide maximum operator flexibility in deploying vEPC functions in large or small increments wherever and whenever they are needed
- Capacity support for mobile broadband services with the same level of performance to meet end-user experience expectations
- Network availability and reliability that is as good or better than that provided by the existing packet core, thanks to new protection schemes
- Common operations management of the network functions across the virtualized and physical EPC

Cloud-optimized architecture

In the virtualized architecture of the Alcatel-Lucent vEPC, the product functions of the IP Mobile Core are decomposed into virtualized sub-functions that are hosted on individual virtual machines. Different VM types are defined to perform different virtual sub-function tasks.

All of the virtualized functions in the vEPC use the same field-proven application software that's in the IP Mobile Core products. This ensures uniformity and consistency between the virtualized and non-virtualized mobile core functions and operations.

By also supporting open interfaces and being NFV hardware platform-agnostic, the vEPC provides multi-tenancy flexibility where multiple network functions can be configured to operate on the same infrastructure.

Scalability

Providing elastic scaling is at the heart of the vEPC network functions. The vEPC can scale the subscriber context and control plane processing states of the vMME/vSGSN, the bearer management/PDP context and data plane states of the vSGW, vPGW/vGGSN, and the bearer and subscriber policies of the vPCRF.

Being able to horizontally scale beyond the physical limits of the dedicated hardware platforms is one of the key attributes of the vEPC architecture. Flexible scaling can be configured in small or large increments to align with the granularity and precision that the MNO needs to tune their service processing requirements.

Additional VM CPU resources can be dynamically added to meet increasing subscriber demands when utilization thresholds are reached. Load balancing and distribution functions among a group of VMs ensure that no one VM gets overloaded.

Performance

High-capacity and high-performance packet processing are key packet core requirements, and the Alcatel-Lucent vEPC delivers on both. The packet processing and forwarding functions are optimized within the vEPC architecture.

These functions can also be scaled to match the subscriber context, the number of bearer management VMs on the user side as well as the throughput capacity requirement from the network. Using the Intel® Data Plane Development Kit (DPDK) for these I/O and packet forwarding functions, a "fast path" is created between the VM and the physical network interface card (NIC) that improves the data path processing performance. Single Root I/O Virtualization (SR-IOV) is also used in conjunction with DPDK to provide NIC-to-VM direct connectivity, bypassing the hypervisor and improving packet forwarding performance.

Availability and reliability

High availability and reliability of the packet core are critical. In the Alcatel-Lucent vEPC, all the virtual network functions are configured in a fully redundant protection scheme. As a result, the baseline reliability and high availability of the virtualized functions is the same as on the physical products, with no single point of failure.

Operations management

A centralized VM provides system management, monitoring and reporting of the signaling and control functions. This VM also provides a single interface to the virtual function EMS, the cloud orchestration system and any OSSs/BSSs.

EMS requirements for the vEPC

The EMS of the vEPC will be required to manage the virtualized network functions and also to coordinate the management of these functions between the underlying NFV infrastructure VMs and the cloud management system. This introduces additional operational complexity and drives additional requirements:

- To optimize network efficiency for the vEPC, MNOs are faced with the challenge of adjusting network management systems, workflows and processes to most efficiently manage this hybrid network.
- To optimize operations, MNOs will require a unified, end-to-end view across multi-technology layers, including virtualized functions. They will need the flexibility to logically divide and control workflows between virtual and non-virtual network domains and to be able to manage and monitor both technologies seamlessly from a unified perspective.
- The EMS for the vEPC together with the cloud management system must provide fault correlation and root-cause analysis with service impact notifications across the application and virtual infrastructure layers. This capability will allow for quick troubleshooting and restoration of services in case of application or infrastructure faults.

Benefits of the Alcatel-Lucent vEPC

MNOs will see benefits from the use of the IP Mobile Core product software as the foundation of the vEPC core network functions as well as the new features and capabilities afforded by NFV and SDN in the vEPC software design. The benefits of each are as follows.

IP Mobile Core software

Alcatel-Lucent is an industry leader in wireless technology and in the packet core, with over 70 packet core customer networks, including over 40 EPC deployments. Alcatel-Lucent continues to make a significant investment in engineering resources toward the development of its IP Mobile Core software.

This software is designed and optimized to support the unique requirements of the data, signaling and control planes. It is deployed in some of the world's largest mobile networks, including Verizon Wireless®, AT&T, Sprint and China Mobile.

This field-proven software contains an extensive list of advanced features that reduce network signaling, enhance reliability and provide agile policy rules and integrated mobile gateway capabilities to enable new and enhanced services.

IP Mobile Core vEPC software

The vEPC software is multivendor and open to run on any NFV infrastructure and leverage any cloud orchestration system and SDN offering. It gives MNOs the maximum level of freedom to select the best-of-breed component for each part of their NFV cloud architecture. All the EPC network functions are virtualized and because the software is based on the IP Mobile Core software, it is fully feature transparent for seamless operations across hybrid core networks, both virtualized and dedicated hardware-based.

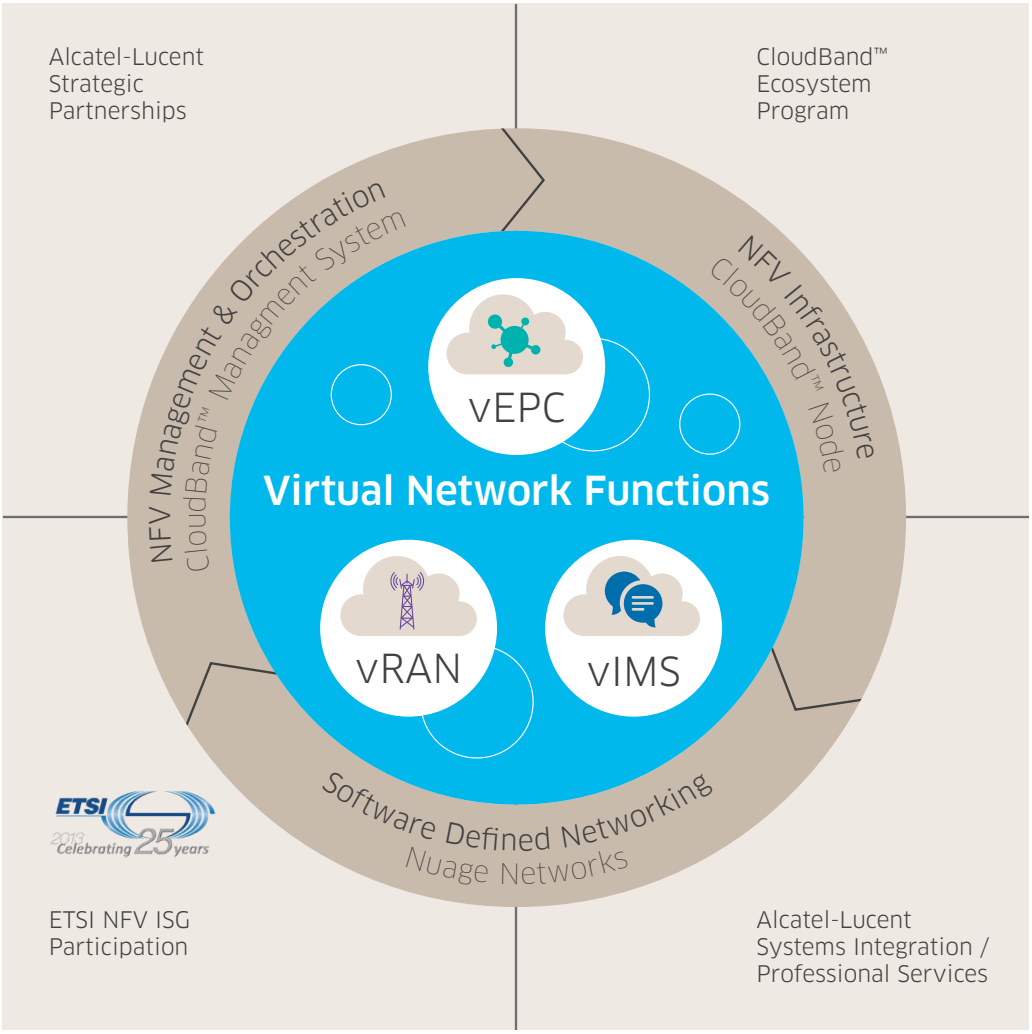
The vEPC network functions take full advantage of the flexibility and capabilities of the cloud network, including new cloud optimizing capabilities to provide increased scaling and packet processing, new protection schemes to deliver redundancy and resiliency, and the ability to quickly turn up new vEPC network functions using cloud automation.

PUTTNG IT ALL TOGETHER: NFV, SDN AND THE vEPC

Alcatel-Lucent recognizes that solving the challenges of transitioning mobile networking to the cloud goes beyond just delivering virtualized mobile network functions. The underlying platform for NFV must also evolve to support the stringent requirements of telecom network functions while providing automation and agility. With this in mind, Alcatel-Lucent is developing solutions across every facet of the NFV environment. In addition to our mobile virtual network functions application software, our NFV portfolio includes NFV management and orchestration; NFV infrastructure with integrated compute, storage, and networking; and SDN.

With exposure to the advantages and challenges in each area, Alcatel-Lucent can bring unique insight into the development of each element. Alcatel-Lucent offers a fully pre-integrated NFV/SDN solution that can speed time to market, and each of the NFV elements is built to operate in an open, multivendor cloud environment (see Figure 2).

Figure 2. Alcatel-Lucent open collaboration and partnerships



As shown in Figure 2, there are four elements to this solution:

- CloudBand Management System
- CloudBand Node (NFV hardware platform)
- Nuage Networks (for SDN)
- EPC Virtualized Network Functions (vEPC)

Alcatel-Lucent CloudBand is an open, multivendor platform that includes CloudBand Node as the NFV infrastructure and CloudBand Management System as the cloud orchestration management system to optimize and automate virtual machines running vEPC.

Alcatel-Lucent offers an SDN solution through its Nuage Networks' venture, which delivers an innovative Virtualized Services Platform software suite to optimize and automate the consumption of data center networking and transport infrastructure resources.

CONCLUSION

As an industry we have begun the journey toward the virtualization of key telecommunications networking functions. The EPC will be one of the first parts of the mobile network to be virtualized, and Alcatel-Lucent is ready to support this transformation with a complete vEPC offer that virtualizes all of the core network functions into a set of software products and licenses.

The vEPC uses as its base the product software of its industry-leading and field-proven IP Mobile Core but also takes full advantage of NFV and SDN in its design approach and architecture. Specifically, the Alcatel-Lucent vEPC addresses the following key requirements of MNOs in its software design:

- Cloud-optimized architecture: The vEPC is multivendor and open and runs on any industry-standard NFV infrastructure.
- Flexible scaling: The vEPC can be configured to support multi-tenancy and can scale horizontally to meet the unpredictable variability in service demands.
- Assured high performance: With its field-proven software, the vEPC delivers the consistent and predictable high performance that is needed in the core network. It also takes advantage, in its virtualized design, of the latest in general-purpose computing advanced packet processing techniques.
- High reliability: The vEPC continues to provide high availability and also supports new protection schemes.
- Operations management: The vEPC provides a common EMS to manage the vEPC and the existing IP Mobile Core.

The transformation to a vEPC will be a significant change in how the MNO operates the network. To succeed in this transformation, MNOs need to partner with vendors that have broad experience in LTE EPC, carrier cloud/NFV and SDN. Alcatel-Lucent has the field experience, knowledge and a full range of products and solutions to make this transformation as smooth as possible.

ACRONYMS

5620 SAM	Alcatel-Lucent 5620 Service Aware Manager
5780 DSC	Alcatel-Lucent 5780 Dynamic Services Controller
7750 SR	Alcatel-Lucent 7750 Service Router
9471 WMM	Alcatel-Lucent 9471 Wireless Mobility Manager
2G, 3G, 4G	Second Generation, Third Generation, Fourth Generation
ANDSF	Access Network Discovery and Selection Function
API	application programming interface
BSS	Business Support System
CAPEX	capital expenditures
CPU	central processing unit
DCP	Diameter Control Point
DPDK	Intel Data Plane Development Kit
DRA	Diameter Routing Agent
EMS	element management system
EPC	Alcatel-Lucent Evolved Packet Core
ETSI	European Telecommunication Standards Institute
GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
HSS	Home Subscriber Server
I/O	input/output
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IPsec	IP Security protocol suite
LAN	local area network
LTE	long term evolution
M2M	machine-to-machine
MME	Mobility Management Entity
MNO	mobile network operator
MPLS	Multiprotocol Label Switching
NFV	Network Functions Virtualization
NFVI	NFV Infrastructure
NIC	network interface card
OAM	operations, administration and maintenance
OPEX	operating expenditures
OS	Operating System
OSS	Operations Support System
PCRF	Policy and Charging Rules Function
PDN	packet data network
PDP	Packet Data Protocol
PGW	PDN Gateway
PLMN	Public Land Mobile Network
RAN	Radio Access Network
ROI	return on investment
SDN	software-defined networking
SGSN	Serving GPRS Support Node
SGW	Serving Gateway
SLA	Service Level Agreement
SR-IOV	Single Root I/O Virtualization
SR OS	Alcatel-Lucent Service Router Operating System
vDRA	virtualized DRA
vEMS	virtualized EMS
vEPC	Alcatel-Lucent Virtualized EPC
vGGSN	virtualized GGSN
vHSS	virtualized HSS
vIMS	virtualized IMS
VM	virtual machine
vMME	virtualized MME
VNF	virtualized network function
VoLTE	Voice over LTE
vPCRF	virtualized PCRF
vPGW	virtualized PGW
vRAN	virtualized RAN
vSGSN	virtualized SGSN
vSGW	virtualized SGW
Wi-Fi	Wireless Fidelity
WLAN	wireless LAN

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