# Network Functions Virtualization and Diameter Signaling Controllers

## Enabling the telecom network migration to the Cloud!

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# Introduction

The telecommunications industry—and associated network—has typically been characterized by a very methodical and sometimes slow approach to major network/technological changes. Numerous factors have led to this, including:

- Expense in changing network architectures
  - Software costs
  - Purpose-built hardware costs
- Slow process in network protocol standardization
- No consistent worldwide standard for network protocols

Once these networks were deployed, they tended to remain in place and provide fairly consistent feature sets to subscribers for years. This longevity is evidenced by the deployment of the Signaling System 7 (SS7) network in the mid-1980s and its continuing usage today.

The implementation of an all Internet Protocol (IP) network is changing the characteristics of the entire telecommunications network and industry. The rapid deployment of Long Term Evolution (LTE)/Evolved Packet Core (EPC)/Diameter-based mobile networks, coupled with the implementation of Session Initiation Protocol (SIP) Voice over LTE (VoLTE), is a monumental change in the telecom landscape.

The next major telecommunication paradigm shift, Network Functions Virtualization (NFV), is occurring even before the migration to all-IP networks is complete. NFV uses Information Technology (IT) approaches of decoupling applications and software from the hardware on which they reside. Once again telecommunications is learning—or we might say—moving closer to data or IT concepts such as independent hardware servers, Cloud-based services, and all IP networks.

The benefits and objectives of NFV are:

1. Increased network design flexibility
2. Rapid service innovation
3. Reduced capital expenditures
4. Reduced operational costs
5. Reduced power consumption
6. Standardized and open interfaces

Buckle up your seat belts; these are going to be rapid-moving, challenging, changing and exhilarating times for the telecommunications industry. The remainder of this paper will cover NFV, especially as it relates to the Diameter Protocol and Diameter Signaling Controllers (DSCs).

# Business Challenges/Drivers

As with any new technology or approach, industry analysis projections vary:

- Mind Commerce reported in "Network Functions Virtualization (NFV) Market: Business Case, Market Analysis & Forecasts 2014 – 2019" that revenues for NFV would be $203 million in 2014 and grow with a CAGR of 46% between 2014 and 2019. NFV revenues will be $1.3 billion by the end of 2019.
- Infonetics Research reported that the NFV and Software-defined networking (SDN) market will grow from less than $500 million in 2013 to over $11 billion in 2018, and that NFV represents the lion's share of the combined SDN and NFV market from 2014 out to 2018
- TechNavio's analysts forecast the Global Network Functions Virtualization market to grow at a CAGR of 51.57 percent over the period 2013-2018.

Regardless of which market research company says what, the result of all market research is that NFV is in its infancy, and it is going to grow rapidly from 2015 into the foreseeable future.

# Introduction to Network Functions Virtualization

Formal discussions around NFV started with a white paper published by European Telecommunications Standards Institute (ETSI) in October of 2012 titled "Network Functions Virtualization—An Introduction, Benefits, Enablers, Challenges & Call for Action." There were thirteen members representing worldwide service providers that started this discussion. Currently, there are more than 250 members/participants, from service providers to network equipment/software vendors to universities. Additionally, there are 17 ETSI specifications in GS NFV series.

## NFV Definition

NFV is defined by ETSI as the principle of separating network functions from the hardware they run on by using virtual hardware abstraction.

The main concepts in the NFV methodology are to:

1. Move network functions from proprietary hardware appliances to commercial off-the-shelf hardware.
2. Shift control of network functions from software to hardware by using a hypervisor layer that abstracts the software functions.
3. Provide flexibility across locations—datacenters and other network nodes—to maximize efficiencies and performance.
4. Create a more applications-aware network to facilitate a reduction in time required to build out services.

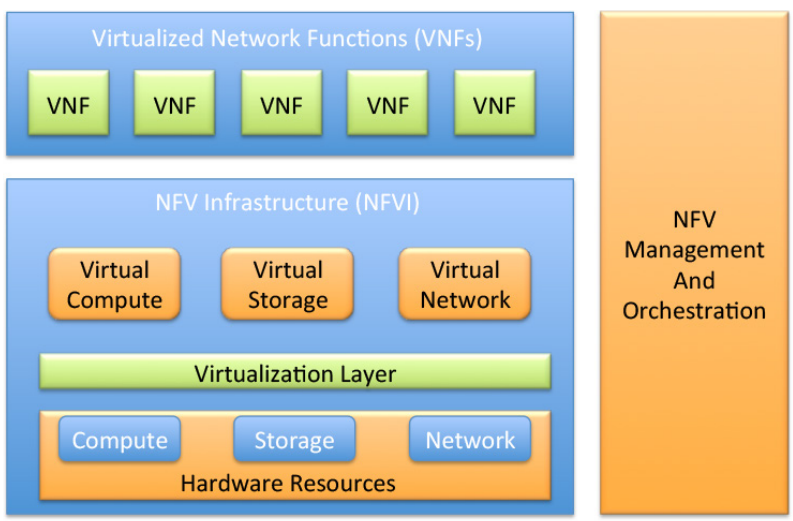
## High-Level NFV Framework

The following discussion is not meant to be a detailed tutorial on NFV, but rather an introduction to the high-level NFV concepts to facilitate the upcoming discussion on NFV and DSC use cases.

The high-level NFV framework graphic depicts three major categories within NFV: Virtualized Network Functions (VNFs), NFV Infrastructure (NFVI), and NFV Management and Orchestration.

As defined in ETSI GS NFV 002, V1.2.1 (2014-12):

- VNF is the software implementation of a network function, which is capable of running over the NFVI.
- NFVI includes the diversity of physical resources and how these can be virtualized. NFVI supports the execution of the VNFs.
- NFV Management and Orchestration covers the orchestration and lifecycle management of physical and/or software resources. This capability covers NFVI, and the lifecycle management of VNFs. NFV Management and Orchestration focuses on all virtualization-specific management tasks necessary in the NFV framework.




High-level NFV Framework

## NFV Infrastructure (NFVI)

The NFVI is the combination of all hardware and software and is used to implement the VNFs. This infrastructure can span multiple locations in which case each location is known as an NFVI Point of Presence (PoP). The network providing connectivity between NFVI-PoPs is regarded as a part of the NFVI.

**Hardware Resources**
Hardware resources include physical computing, storage, and network resources to support the VNFs through the Virtualization Layer, also known as the Hypervisor.

In the case of NFV, computing hardware is assumed to be commercial off-the-shelf (COTS) rather than purpose built hardware. Network resources include switching functions like routers and links, either wired or wireless.

The NFV concept divides the network into two categories.

1. The network resources used to interconnect computing and storage resources within an NFVI-PoP. Network resources providing external access are included in this category.
2. Network transport resources used to interconnect NFVI-PoPs, whether they are:
   - Within the same network
   - Owned by the same network operator
   - Owned by a different network operator
   - Used to interconnect to other network appliances not contained in an NFVI-PoP

**Virtualization Layer**
The Virtualization Layer is used to ensure that the VNFs are decoupled from the hardware resources. This concept allows the VNF software to be deployed on different hardware resources. The Virtualization Layer functionality is provided by hypervisors or virtual machines.

**Virtualized Resources**
Virtualized instances of hardware resources are abstracted from the physical resources by the virtualization layer or hypervisor.

Virtualized network paths are used to provide connectivity between Virtual Machines (VMs) of a VNF or between different VNFs. Virtualized network connectivity can be provided by:

- Virtual Local Area Network (VLAN)
- Virtual Private LAN Service (VPLS)
- Virtual Extensible Local Area Network (VxLAN)
- Network Virtualization using Generic Routing Encapsulation (NVGRE)
- And others

**Virtualized Network Functions (VNFs)**
Network functions are defined by industry specifications form ETSI, IETF, 3GPP and others. These specifications define the functional behavior as well as the network interfaces. Within the NFV concept, VNFs are software packages that implement network functions in a virtualized environment.

**NFV Management and Orchestration**
NFV Management and Orchestration include the capabilities to provide:

- End-to-End service to End-to-End NFV mapping
- Instantiating VNFs at the appropriate locations
- Instantiating VNFs under the appropriate conditions
- Allocation and scaling of hardware resources to the VNF
- Tracking VNF instances
- And others

# Diameter NFV Use cases

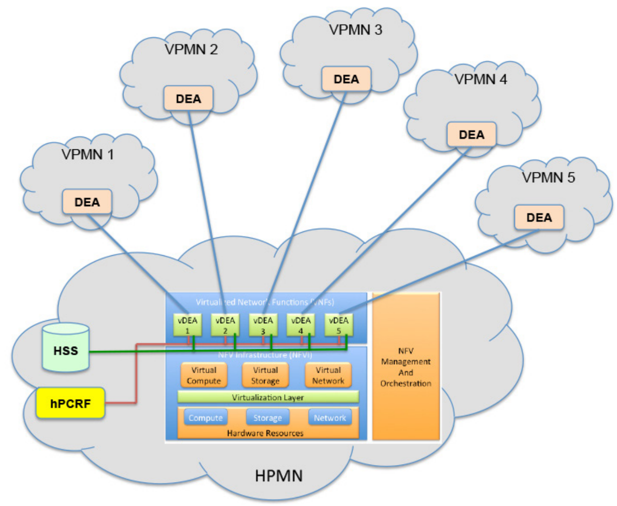
The use cases discussed in this section are meant to provide examples of the use of NFV concepts in the Diameter routing arena. There are and will continue to be more NFV/Diameter routing use cases defined as vendors and service providers move forward with NFV in the LTE environment, including both Diameter and Session Initiation Protocol (SIP) protocols.

## Diameter Edge Agents – Service Providers

**Problem:** As more and more network operators sign bilateral roaming agreements, the management of these inter-connected networks is becoming problematic in terms of security, topology hiding, traffic handling and the costs associated with purpose-built Diameter Signaling Controllers.

**Solution:** This use case depicts a network operator who has multiple bilateral roaming agreements with other network operators. The home network operator has chosen to use NFV capabilities for the Diameter Edge Agents (DEA). Each instantiation of the virtual DEA (vDEA) can provide:

- Routing on an interconnected network basis
- Security mechanisms tailored to interconnected networks
- Screening of incoming messages by interconnected networks
- Traffic shaping based on individual service level agreements (SLAs)
- CapEX savings over individual purpose built-platforms
- OpEX savings
- Reduction in risk; changes to one network parameter do not affect other interconnected networks



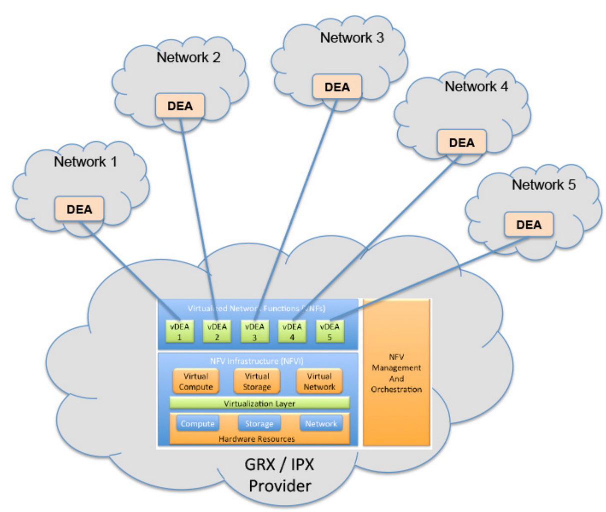

Service Provider with bilateral Roaming Agreements

## Diameter Edge Agents – IPX Providers

**Problem:** The IPX/GRX market is growing, driven by the increases in roaming agreements between network operators. This growth can have an adverse effect on IPX/GRX providers' ability to effectively manage the interconnections in terms of operations, security, and capital expenditures for DSCs. Additionally, not all DSCs have segmentation ability to address multiple tenants.

**Solution:** This use case depicts an IPX/GRX operator who has multiple network operator clients. The IPX/GRX network operator has chosen to use NFV capabilities for the Diameter Edge Agents. Each instantiation of the vDEA can provide:

- Routing on an interconnected network basis
- Security mechanisms tailored to interconnected networks
- Screening of incoming messages by interconnected networks
- Traffic shaping based on individual SLAs
- CapEx savings over individual purpose-built platforms
- OpEx savings
- Reduction in risk; changes to one network parameter do not affect other interconnected networks




IPX/GRX Provider – Multiple Interconnected Networks

## Core Diameter Signaling Controllers – Traffic Scenario

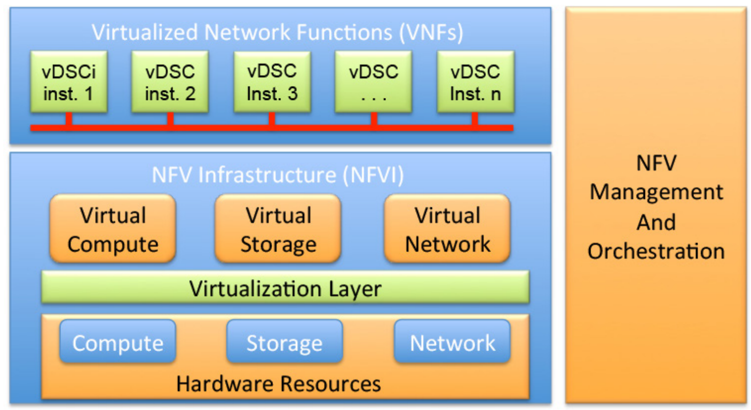
**Problem:** The industry-coined phrase "Diameter Signaling Storm" describes an exponential increase in Diameter traffic as the LTE subscriber subscription rates increase. Addressing the increase in Diameter traffic using conventional DSCs based on purpose-built hardware platforms requires that the DSC be engineered for the worst-case traffic scenario. This concept of over-engineering reduces the need for in-service upgrades, but adds significantly to the equipment costs.

**Solution:** The NFV-based core DSC in this use case instantiates Virtualized Diameter Signaling Controller (vDSCs) instances based on real-time traffic requirements. Since most network signaling traffic, including Diameter, is not constant, the vDSC can de-instantiate instances based on a reduction in traffic. This concept saves:

- Operations costs in commissioning new processing capabilities
- Capital costs in purpose-built computing power

Diameter Signaling Controller

Instantiated based on Real-time Traffic Demands

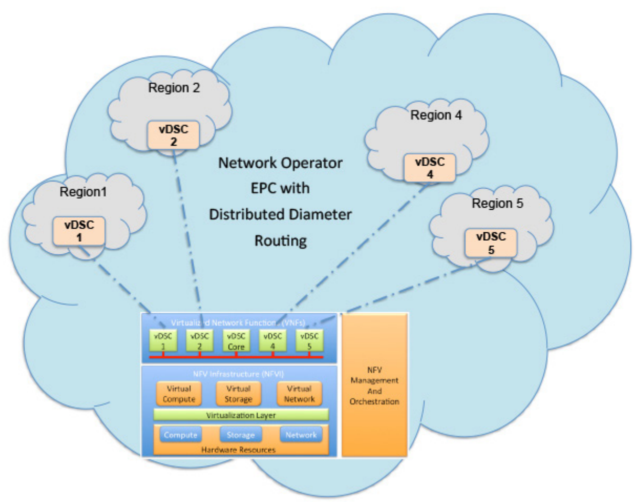



Core Diameter Signaling Controller – Traffic Based Instantiation

## Core Diameter Signaling Controller – Network Distribution Scenario

**Problem:** Some network operators would rather design, implement and manage their networks on a regional basis; however, the logistics and costs of purpose-built DSCs is a determent to this concept.

**Solution:** An NFV-virtualized DSC, including vDSC for each region and a core vDSC, provides a cost-effective solution to the regionalization of Diameter Routing. This solution can also be implemented in the case where the core DSC is already in place, whether it is virtualized or a purpose-built platform.




Regionalization of Diameter Routing using NFV- based Diameter Signaling Controllers

# Conclusion

The promise of NFV is to provide:

1. Reduced capital expe nditures
2. Increased network design flexibility
3. Rapid service innovation
4. Reduced operational costs
5. Reduced power consumption
6. Standardized and open interfaces

These are lofty but very achievable goals, as evidenced by the use cases listed in this paper. However, this is merely the starting point, especially as it relates to LTE/EPC/Diameter-based networks and VoLTE/SIP-based networks. Since DSCs are the hub for all Diameter protocol connections, future NFV-enabled capabilities can be envisioned, including:

1. Virtualized Services Orchestration
2. SLA Assurance applications
3. And many others

The combination of NFV and SDN will open up even more unforeseen capabilities for network service providers and subscribers. What an exciting time for telecommunications!

# What to Look for in an NFV-based Diameter Signaling Controller

## NFV

The DEA should include the ability to be deployed virtually (NFV) or as an appliance to meet network operators' desire to reduce costs and use new hypervisor and orchestration technologies concepts.

## Vendor involvement in NFV standardization

In order for telecommunications vendors to be in the forefront of new and evolving concepts such as NFV and SDN, it is important that they be actively involved in the standardization process. Their involvement ensures that they are committed to the concept and knowledgeable about upcoming changes in standards. This commitment will be reflected in the vendor's implementation of standards within their products.

## Routing Segmentation

The DEA should include the ability to segment the routing rules on a per-interconnected-network basis. This segmentation would provide the ability to administer routing rules, traffic shaping, Diameter-to-Diameter interworking, and Diameter-to-SS7 interworking on a roaming partner or interconnected network basis. This capability allows increased control, reduces administrative risks and provides the flexibility required in network design.

## Independence – Specializing on Network Signaling & Routing

There will always be differences in the implementation and interpretation of specifications when any network or protocol is deployed. These differences can cause catastrophic problems within networks and across the boundaries between different networks. A network equipment vendor that specializes in protocols and routing can provide mediation capabilities which solve the protocol inconsistencies and thus eliminate their network impact.

# Sonus Advantage

## Sonus DSC SWe (Software edition)

The DSC SWe delivers the same advanced features and functionality of Sonus' hardware-based (DSC in a virtualized platform, delivering greater deployment flexibility for network operators. NFV plays an increasingly critical role in today's next-generation and Cloud networks. Building upon its strategy to virtualize the field-proven code base of its industry-leading hardware platforms, Sonus separated its Diameter software from the DSC 8000 hardware and architected it to operate on industry-standard COTS servers. For customers looking to leverage new and existing platforms to support NFV functionality, the DSC SWe allows customers to deploy a fully-featured DSC co-resident with other applications.

## Sonus' Involvement in Standards

Sonus has been an active member of ETSI for about a decade now, and was involved in much of the ETSI TISPAN work that fed into IMS. More recently, Sonus has been focusing on the NFV ISG and is an active member of the MANO working group contributing to the documents being worked on. Sonus feels this is an important forum to shape the approach vendors and operators take towards virtualizing software. As a pioneer in bringing high-performance-real-time software into hypervisors, Sonus' technical and real-world knowledge can help shape the standardization work and ensure it results in effective solutions.

In addition to this, Sonus is active at 3GPP, IETF and OPNFV, and has a high degree of interest in OpenFlow, OpenDaylight and OpenStack.

## Sonus DSC 8000 "Virtual Instances"

The DSC 8000 enables the definition of separate DEAs within a single DSC 8000 platform. Each of these virtual DEAs has its own separate routing and screening rules that include the ability to shape traffic on a per-peer basis. This shaping includes traffic flow control, throttling and congestion per-peer. Architected for extensibility and straightforward evolution to future Diameter applications, this high-powered platform makes DSC 8000 ideal for LTE/EPC and IMS networks.

## Specializing in Telecommunications Signaling and Routing Solutions

Sonus' focus on signaling and routing solutions, combined with its expertise in SS7, SIP and Diameter protocols, provides the objectivity required to deliver the most efficient SS7, SIP and Diameter interworking capabilities in the industry.

## About Sonus Networks

Sonus brings intelligence and security to real-time communications. By helping the world embrace the next generation of Cloud-based SIP and 4G/LTE solutions, Sonus enables and secures latency-sensitive, mission-critical traffic for VoIP, video, instant messaging and online collaboration. With Sonus, enterprises can give priority to real-time communications based on smart business rules, while service providers can offer reliable, comprehensive and secure on-demand network services to their customers. With solutions deployed in more than 100 countries and nearly two decades of experience, Sonus offers a complete portfolio of hardware-based and virtualized Session Border Controllers (SBCs), Diameter Signaling Controllers (DSCs), Network-as-a-Service (NaaS) capabilities, policy/routing servers, and media and signaling gateways.


**Sonus Networks North American Headquarters**
4 Technology Park Drive
Westford, MA 01886
U.S.A.
Tel: +1-855-GO-SONUS

**Sonus Networks APAC Headquarters**
1 Fullerton Road #02-01
One Fullerton
Singapore 049213
Singapore
Tel: +65-68325589

**Sonus Networks EMEA Headquarters**
Edison House
Edison Road
Dorcan, Swindon
Wiltshire
SN3 5JX
Tel: +44-14-0378-8114

**Sonus Networks CALA Headquarters**
Homero No. 1933-902
Col. Los Morales, C.P. 11510
Mexico City, Mexico
Distrito Federal
Mexico Tel: +52-55-1950-3036
Int'l Tel: +1-978-614-8741


To learn more, call Sonus at 855-GO-SONUS
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