Network Function Virtualization (NFV)

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References


3. ETSI Specifications on NFV Use Cases, GS NFV 001, 2013-10
Network Function Virtualization

- Motivation
- Principles and Use Cases
- Architecture and Business model
- NFV, Cloud and SDN
Network Function Virtualization

- Work initiated in 2102 and mostly done by an industry consortium: The European Telecommunications Standards (ETSI)
Motivation
Motivation

Address the problem paused by the proliferation of middleboxes in current networks (i.e. cost)
Middleboxes

Definition:
- Specialized hardware that performs a network service
  - Network service
    “Anything” which is not packet forwarding
Middleboxes

Examples:
- Network Address Translation (NAT)
- Firewall
- Deep Packet Inspection (DPI)
- Encryption
- Decryption
- IP address assignment (e.g. DHCP)
- Customer Premise Equipment (CPE)
Customer Premise Equipment

The specific case of customer premise equipment (CPE)
- Equipment installed at customer premises but belonging to a service provider
  - Might be residential or corporate
    - TV set up boxes
    - Firewalls
    - NAT
- A typical CPE has typically several functions in a single hardware boxes.
Customer Premise Equipment (Ref. 1)

Fig. 1. Traditional CPE implementations.
Cost Issues Related to Middleboxes
(As illustrated by the CPE)

Examples
- High purchasing cost
- High maintenance cost
  - Highly specialized maintenance staff
  - Need to physically go to customer premises (or discuss with customers) to add / remove / upgrade function
- Short life cycle
NFV Vision
(As illustrated by the CPE – Ref 1)

Fig. 2. Possible CPE Implementation with NFV
NFV Solutions to Cost Issues (As illustrated by the CPE)

NFV Solution: Network Function Decoupled From Hardware and implemented as Virtual Network Function (VNF) running on commodity hardware:
NFV Solutions to Cost Issues
(As illustrated by the CPE)

Advantages:
- Lower purchasing cost, software costing less than specialized hardware
- Lower maintenance cost
  - Could run and be operated anywhere including service provider premises
  - Short life cycle
Principles and Use Cases
Principles

- Decoupling of physical network equipment from the functions they run
  - Functions are known as Network Functions
    - Examples of Network Functions
      - Routing
      - Firewall
      - DHCP
      - NAT
      - UPnP
Principles

- Leveraging of virtualization to implement the network functions
  - Virtual Network Functions
    - Examples
      - vRouting
      - vFirewall
      - vDHCP
      - vNAT
      - vUPnP
Principles

- Implementation of specific network service by chaining VNFs
  - VNF chains are also known as service chains
Principles

Example of service chain (Reference 2)

Fig. 1. Service Chain.
Principles

From proprietary hardware to VNF in data centres (Reference 2)
Principles

From proprietary hardware to VNF in data centres

- What are the advantages? (Class discussion)
Use Case 1: CPE again (Ref. 3)  
Enterprise setting

Figure 5: Service Provider without virtualisation of the enterprise
Use Case 1: CPE again (Ref. 3)  
Enterprise setting
Use Case 2: CPE again (Ref. 3)
Home setting

Essentially:

- Residential gateways (i.e. NAT, DHCP)

- Set up boxes
Use Case 2: CPE again (Ref. 3)  
Home setting

Figure 20: No Home Virtualisation
Use Case 2: CPE again (Ref. 3)  
Home setting

Figure 21: Home Virtualisation functionality
Use Case 2: CPE again (Ref. 3)
Home setting

Figure 23: Home Virtualisation - Both RGW and STB are Virtualised - Public IP
Use Case 2: CPE again (Ref. 3)
Home setting

Figure 24: Home Virtualisation - Both RGW and STB are Virtualised in Private IP
Use Case 3: Content Delivery Networks

Before
Customer Server

Heavy burden due to high traffic

Slow loading times

After
Customer Server

Decreased access leads to less burden on the server

Optimal access times

End User
NTT Com CDN
Cache Server
Use Case 3: Content Delivery Networks
Use Case 3: Content Delivery Networks

What about deploying surrogate servers at ISP premises to be closer to end-users?

- How is it currently done?
  - Dedicated hardware / server physically “manually” deployed at ISP premises (e.g. Netflix Openconnect; Akamai Aurora)
    - Long process
    - Lack of flexibility (e.g. provisioned for peak hours / use)
Use Case 3: Content Delivery Networks

Provisioning with VNFs (Ref. 3)

Figure 26: principle of different vCDN cache nodes deployment in Virtualised environment
Architecture and Business Model
Architecture (Ref. 1)
Architecture

1. NFV Infrastructure (NFVI)
   - Hardware and software environment for deployment and execution of VNFs.
     - Commodity hardware
     - Hypervisor
   - Openstack is currently often used but does not yet meet all performance requirements
2. Virtual Network Function and Services
   - VNF
     - Implementation of an NF deployed on virtual resources (e.g. VM)
   - VNS
     - Implementation of network services as a set of one or more VNF
2. NFV Management and Orchestration (MANO)
   - VNF provisioning (e.g. configuration)
   - VNF life cycle management
   - VNF coordination (e.g. orchestration)
     - Software Defined Networks (SDNs) might be used for the orchestration
Fig. 5. Proposed NFV Business Model
Business Model (Ref. 1)

1. Infrastructure providers:
   - Deploy and manage physical resources on which the virtual resources may be provisioned and leased to telecommunication service providers
     - Could be public data centres provided they meet the performance requirements
     - Could be the telco service provider itself
   - Resources could be provisioned over several domains by coalition of providers.
2. Telecommunication service providers:
   - Lease resources from one or several infrastructure providers
   - Determine how VNFs should be chained to realize specific network services for end-users
Business Model (Ref. 1)

2. and 3. VNF providers and server providers:
   - VNF providers offer software implementation of NF
   - Could be done by third parties or telecommunication service providers
   - Server provider offer commodity servers to infrastructure providers which may be the telecommunication service providers
Business Model (Ref. 1)

5. Brokers
   - Used for publication and discovery
     - VNFs
     - Infrastructures
     - Servers ...

May not exist
Business Model (Ref. 1)

6. Users
   - Final consumers
NFV, Cloud and SDN
NFV, Cloud and SDN (Ref. 1)

Fig. 6. Cloud Computing Service Models and their Mapping to Part of the NFV Reference Architecture

TABLE I

COMPARISON OF NFV IN TELECOMMUNICATION NETWORKS AND CLOUD COMPUTING
### Comparison of NFV in Telecommunication Networks and Cloud Computing

<table>
<thead>
<tr>
<th>Issue</th>
<th>NFV (Telecom Networks)</th>
<th>Cloud Computing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach</td>
<td>Service/Function Abstraction</td>
<td>Computing Abstraction</td>
</tr>
<tr>
<td>Formalization</td>
<td>ETSI NFV Industry Standard Group</td>
<td>DMTF Cloud Management Working Group [36]</td>
</tr>
<tr>
<td>Latency</td>
<td>Expectations for low latency</td>
<td>Some latency is acceptable</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Heterogeneous transport (Optical, Ethernet, Wireless)</td>
<td>Homogeneous transport (Ethernet)</td>
</tr>
<tr>
<td>Protocol</td>
<td>Multiple Control Protocols (e.g. OpenFlow [37], SNMP [38])</td>
<td>OpenFlow</td>
</tr>
<tr>
<td>Reliability</td>
<td>Strict 5 NINES availability requirements [39]</td>
<td>Less strict reliability requirements [40]</td>
</tr>
<tr>
<td>Regulation</td>
<td>Strict Requirements e.g. NEBS [41]</td>
<td>Still diverse and changing</td>
</tr>
</tbody>
</table>
NFV, Cloud and SDN (Ref. 1)

Fig. 8. Logical Layers in a Software Defined Network
## NFV, Cloud and SDN (Ref. 1)

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<tr>
<td>Formalization</td>
<td>ETSI</td>
<td>ONF</td>
</tr>
<tr>
<td>Advantage</td>
<td>Promises to bring flexibility and cost reduction</td>
<td>Promises to bring unified programmable control and open interfaces</td>
</tr>
<tr>
<td>Protocol</td>
<td>Multiple control protocols (e.g SNMP, NETCONF)</td>
<td>OpenFlow is de-facto standard</td>
</tr>
<tr>
<td>Applications run</td>
<td>Commodity servers and switches</td>
<td>Commodity servers for control plane and possibility for specialized hardware for data plane</td>
</tr>
<tr>
<td>Leaders</td>
<td>Mainly Telecom service providers</td>
<td>Mainly networking software and hardware vendors</td>
</tr>
<tr>
<td>Business Initiator</td>
<td>Telecom service providers</td>
<td>Born on the campus, matured in the data center</td>
</tr>
</tbody>
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NFV, Cloud and SDN (Ref. 1)

Fig. 9. Relationship between NFV, SDN & Cloud Computing
The End