Network Function Virtualization (NFV)

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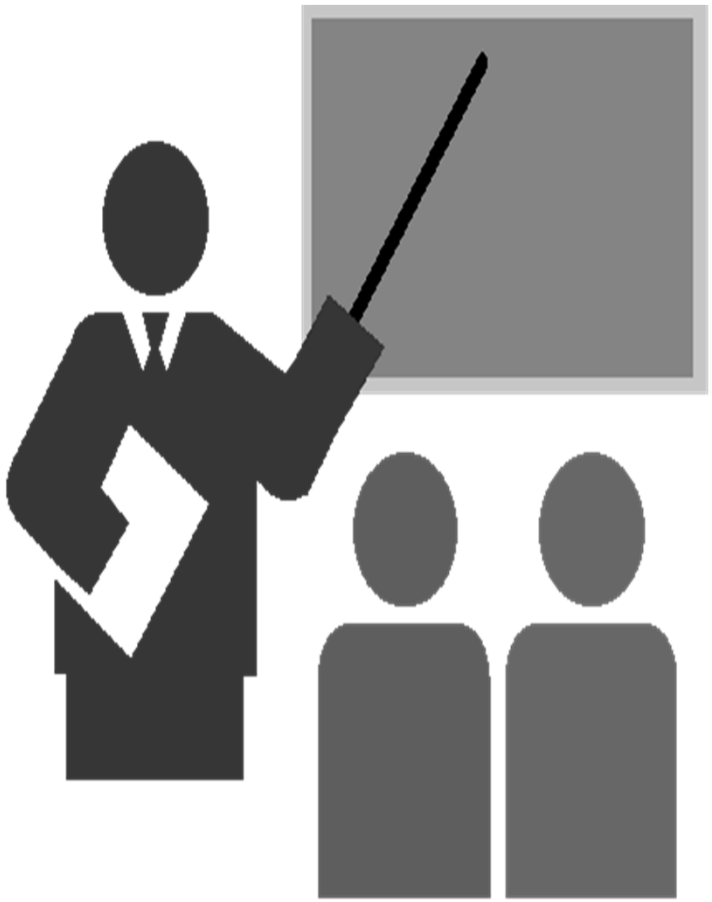
References

1. R. Mijumbi et al., Network Function Virtualization: State of the Art and Research Challenges, IEEE Communications Surveys and Tutorials, First Quarter 2016
2. J.G. Herrera and J.F. Botero, Resource Allocation in NFV: A Comprehensive Survey, IEEE Transactions on Network and Service Management, September 2016
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)

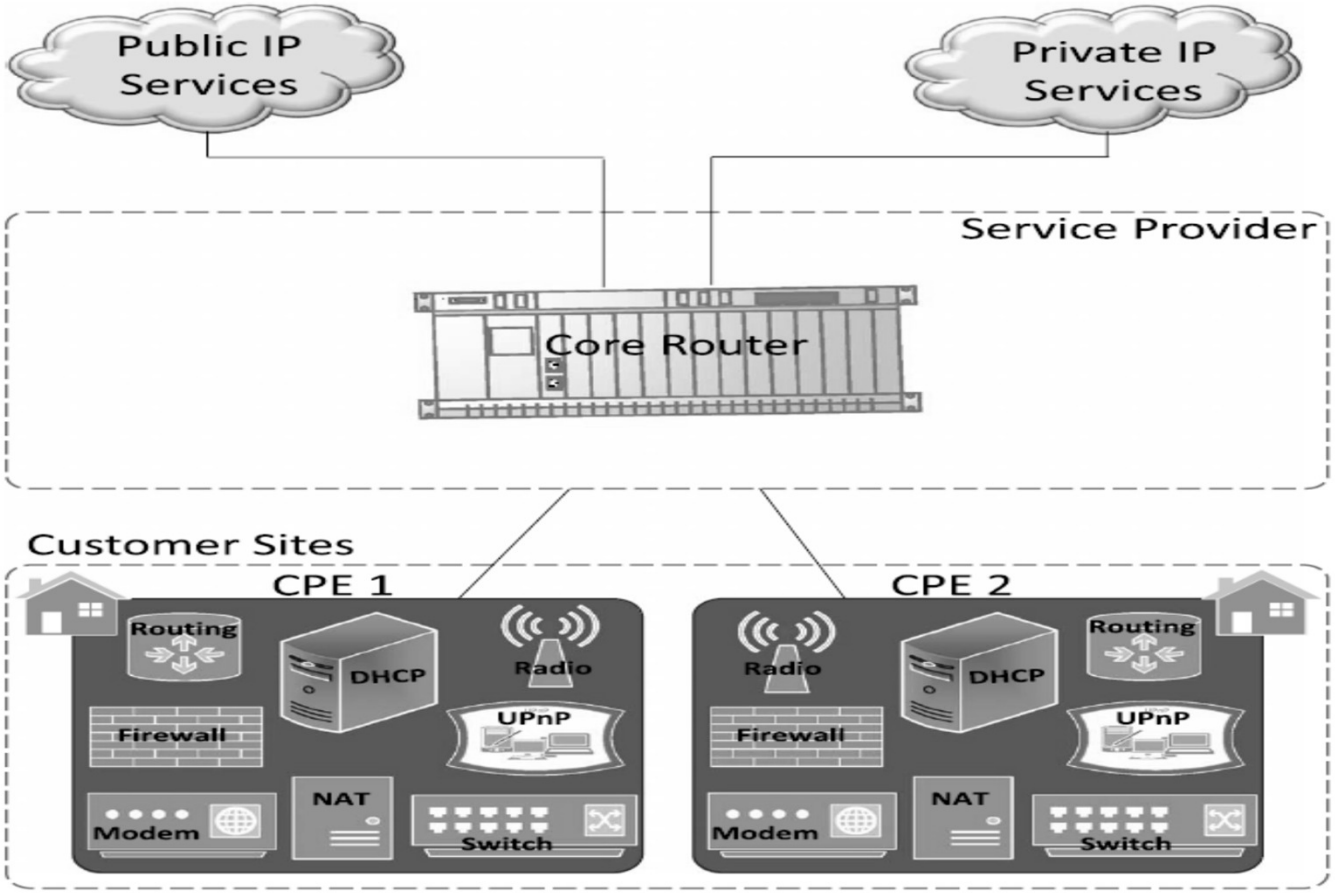


Fig. 1. Traditional CPE implementations.

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)

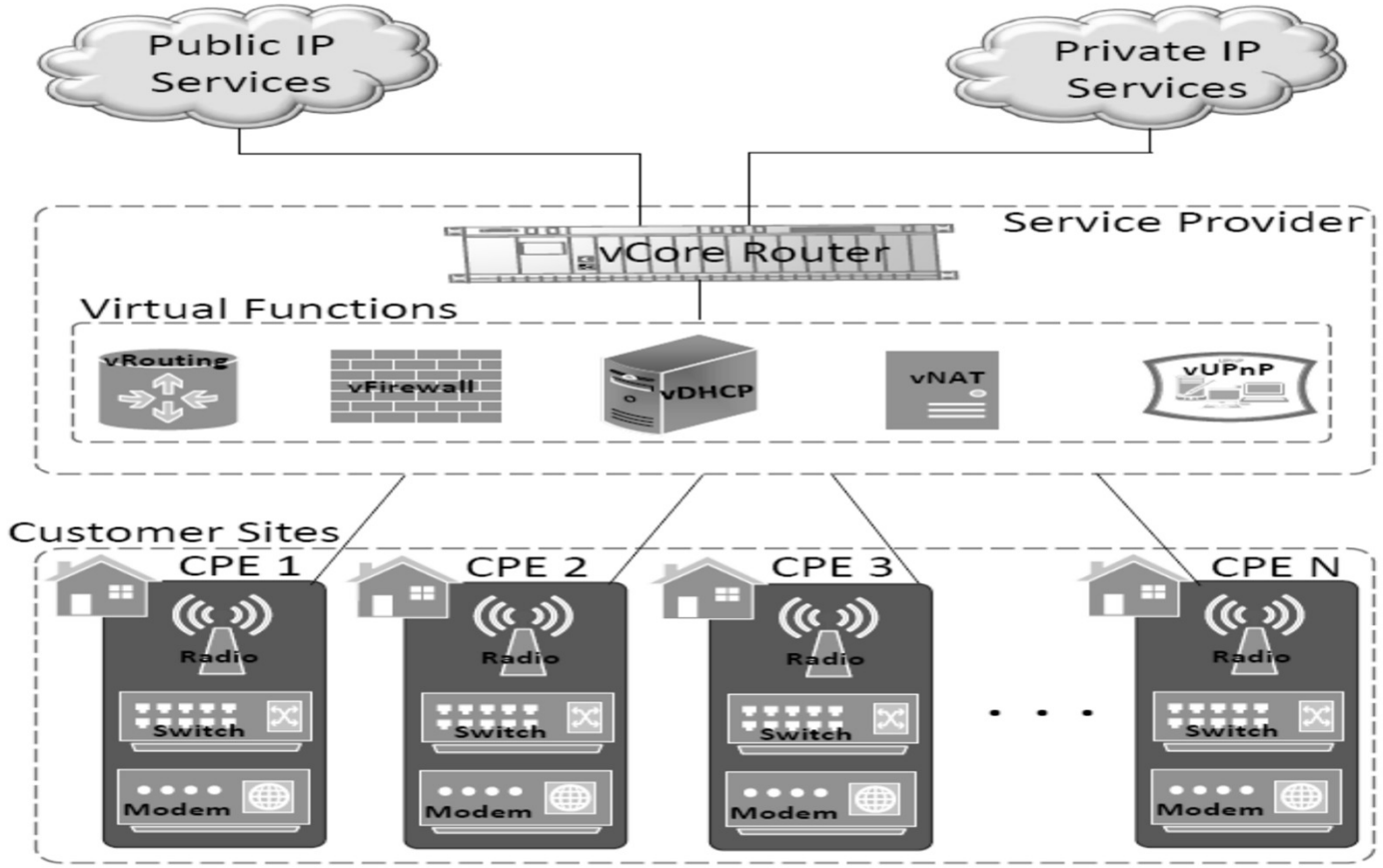


Fig. 2. Possible CPE Implementation with NFV

NFV Solutions to Cost Issues (As illustrated by the CPE)

NFV Solution: Network Function Decoupled From Harware 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)

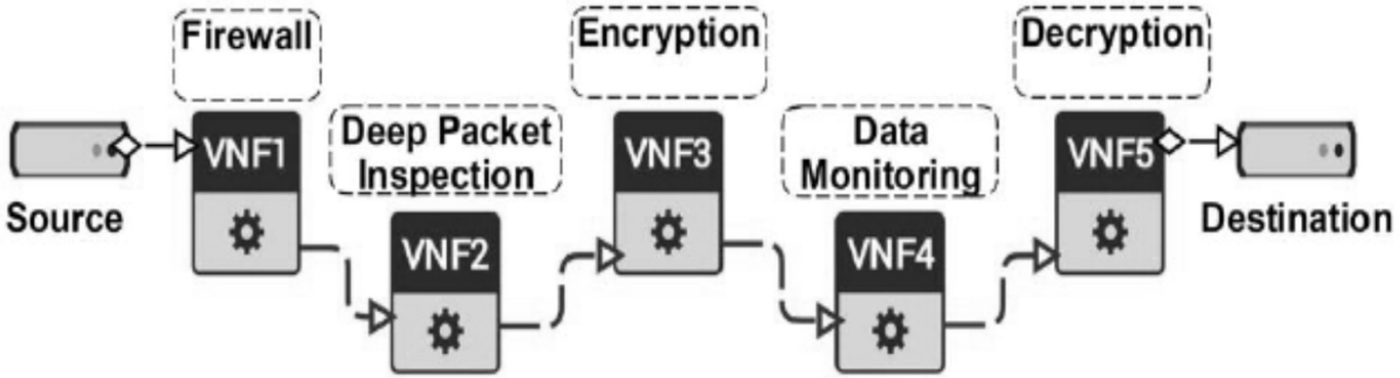
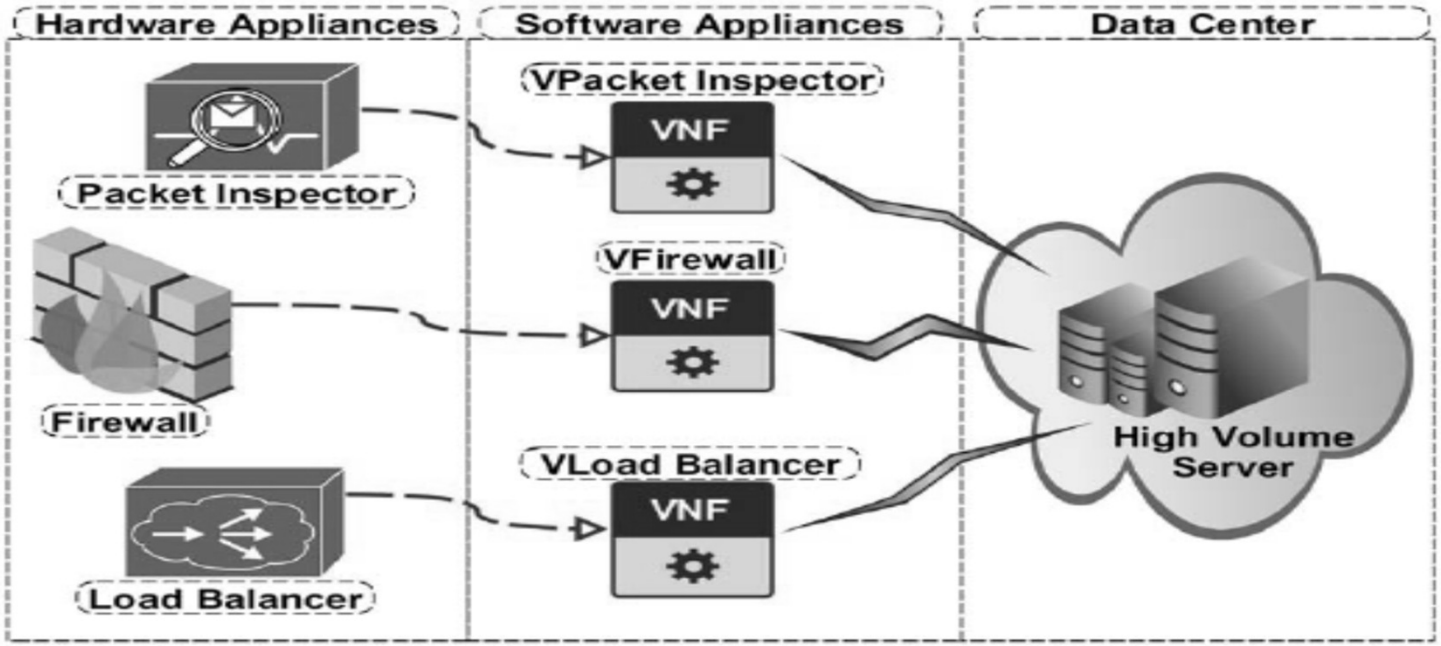


Fig. 1. Service Chain.

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

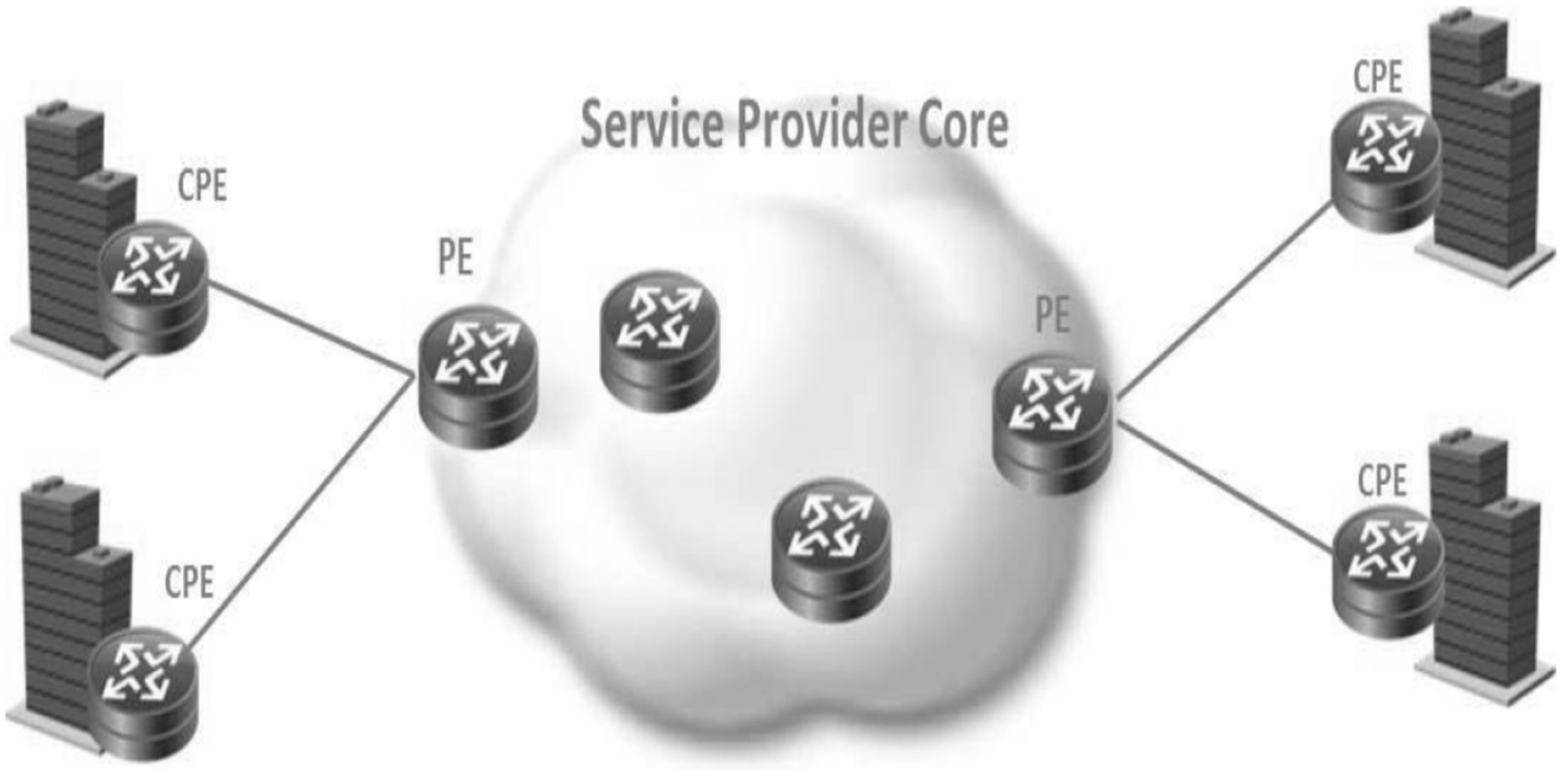


Figure 5: Service Provider without virtualisation of the enterprise

Use Case 1: CPE again (Ref. 3) Enterprise setting

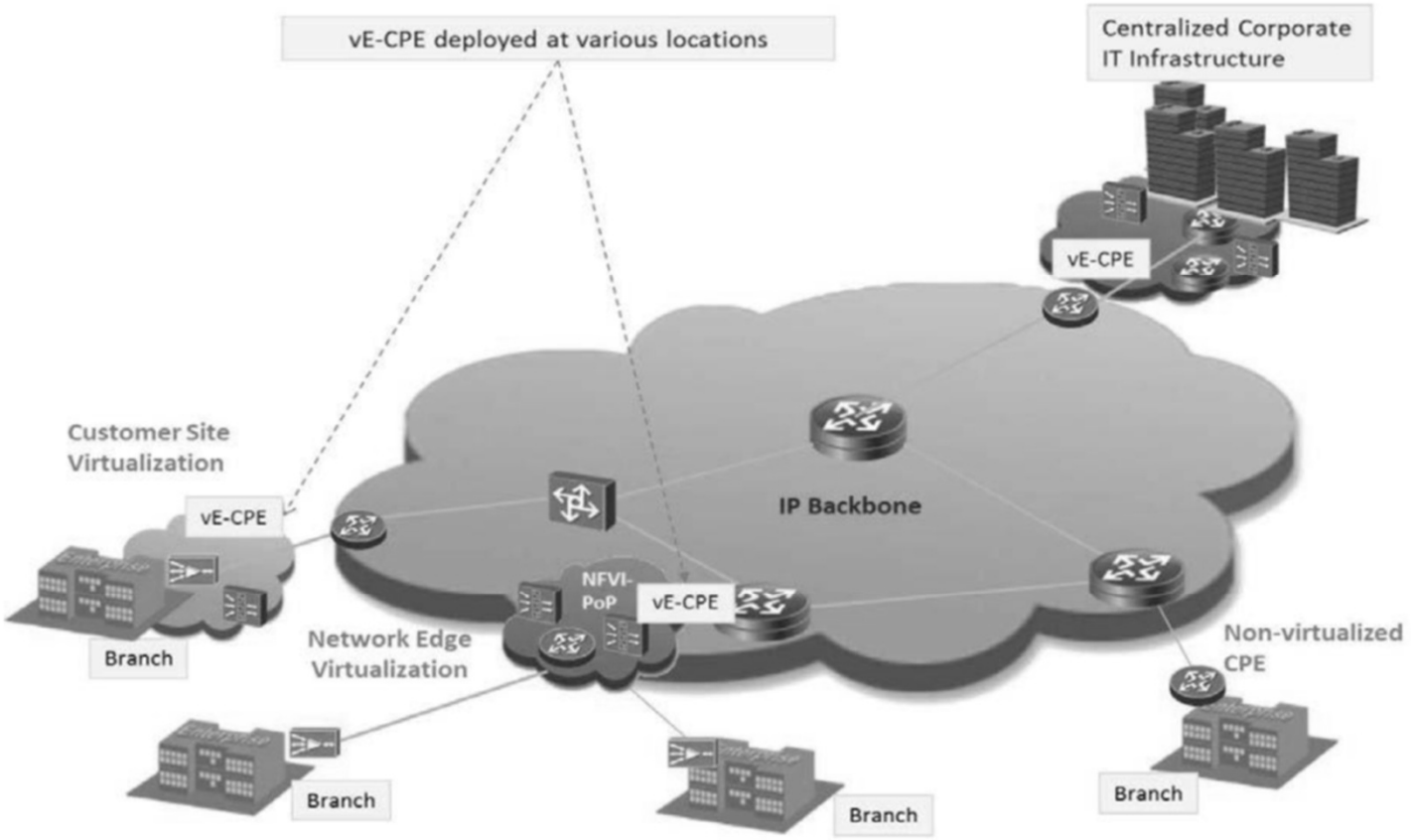


Figure 6: vE-CPE Location Examples

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

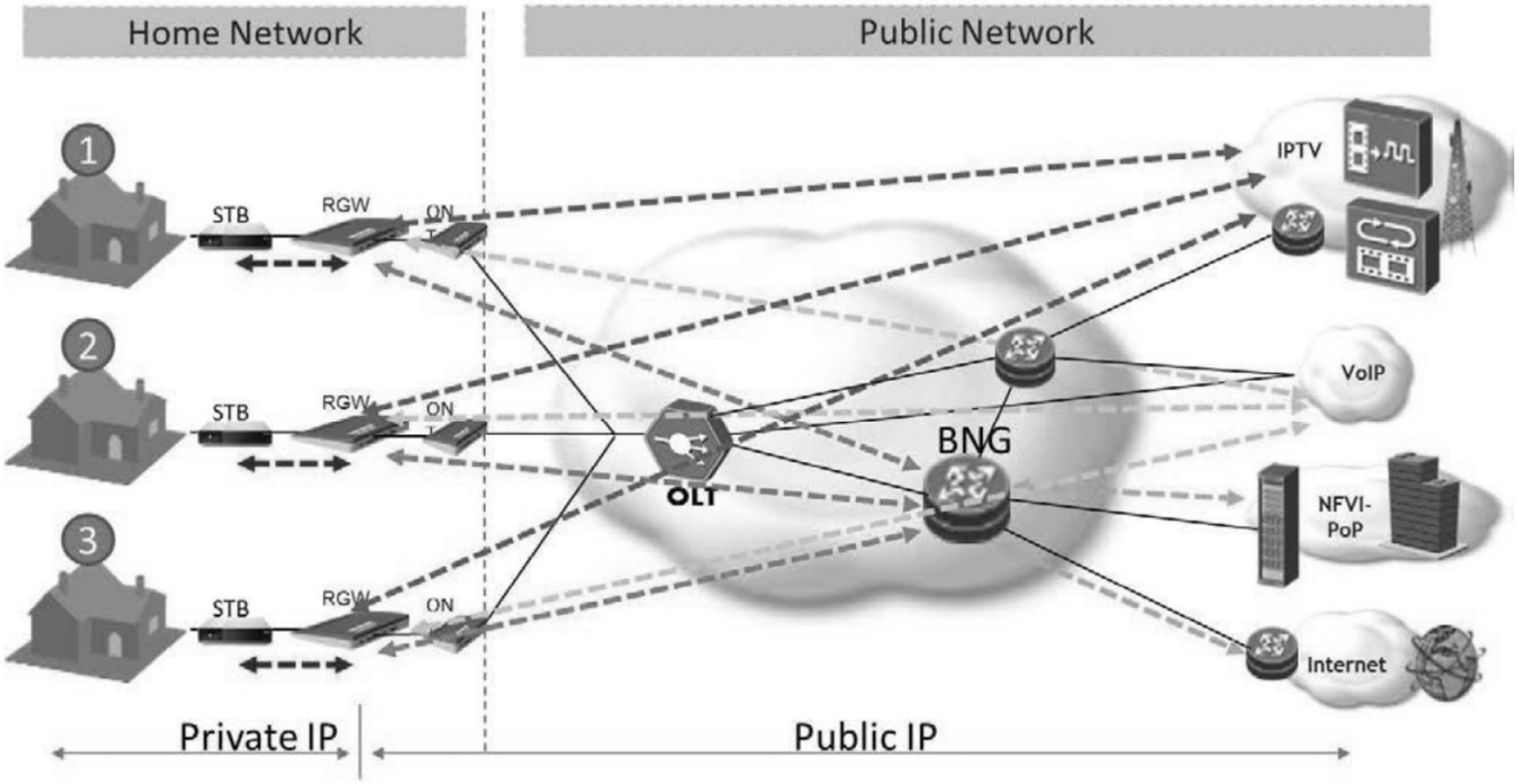


Figure 20: No Home Virtualisation

Use Case 2: CPE again (Ref. 3) Home setting

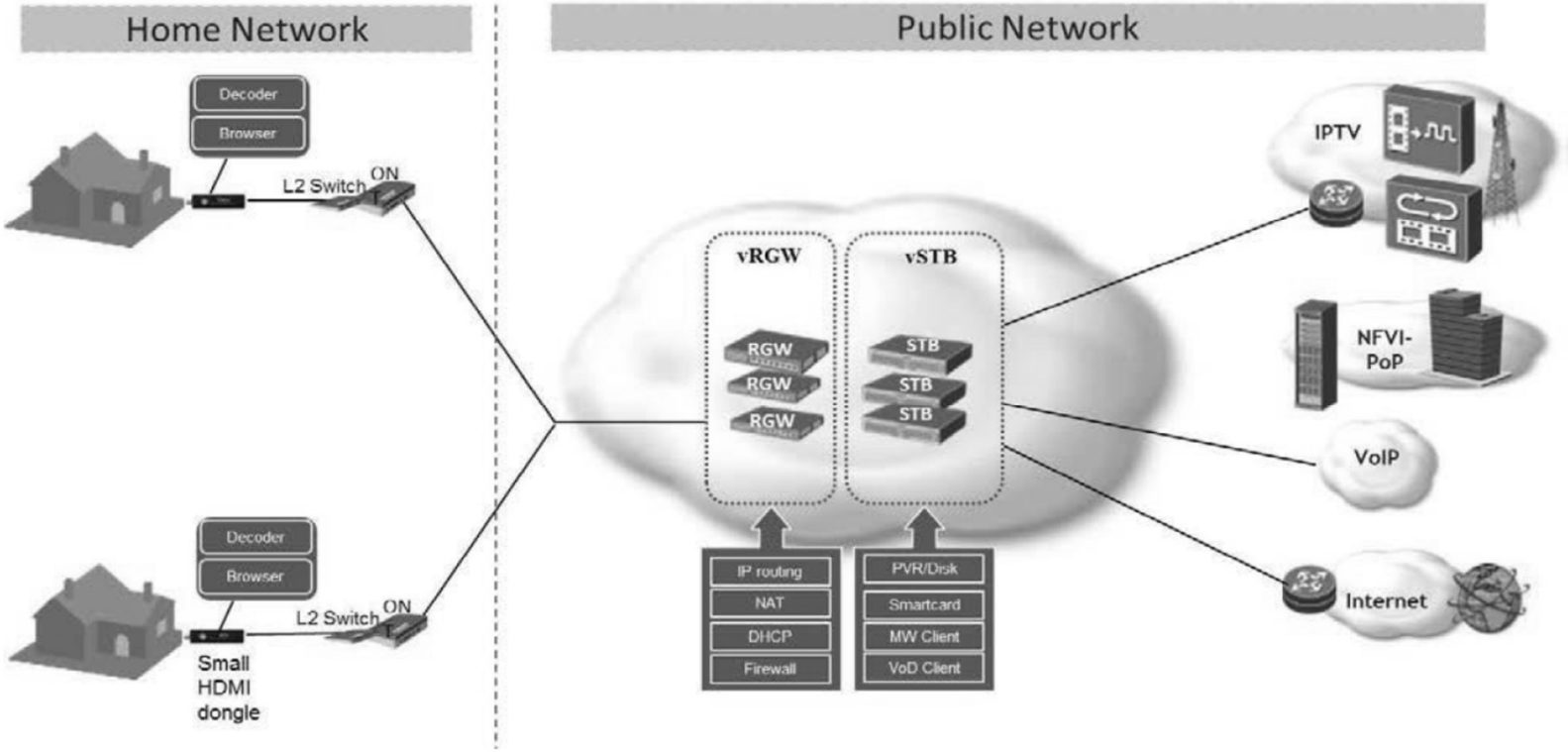


Figure 21: Home Virtualisation functionality

Use Case 2: CPE again (Ref. 3) Home setting

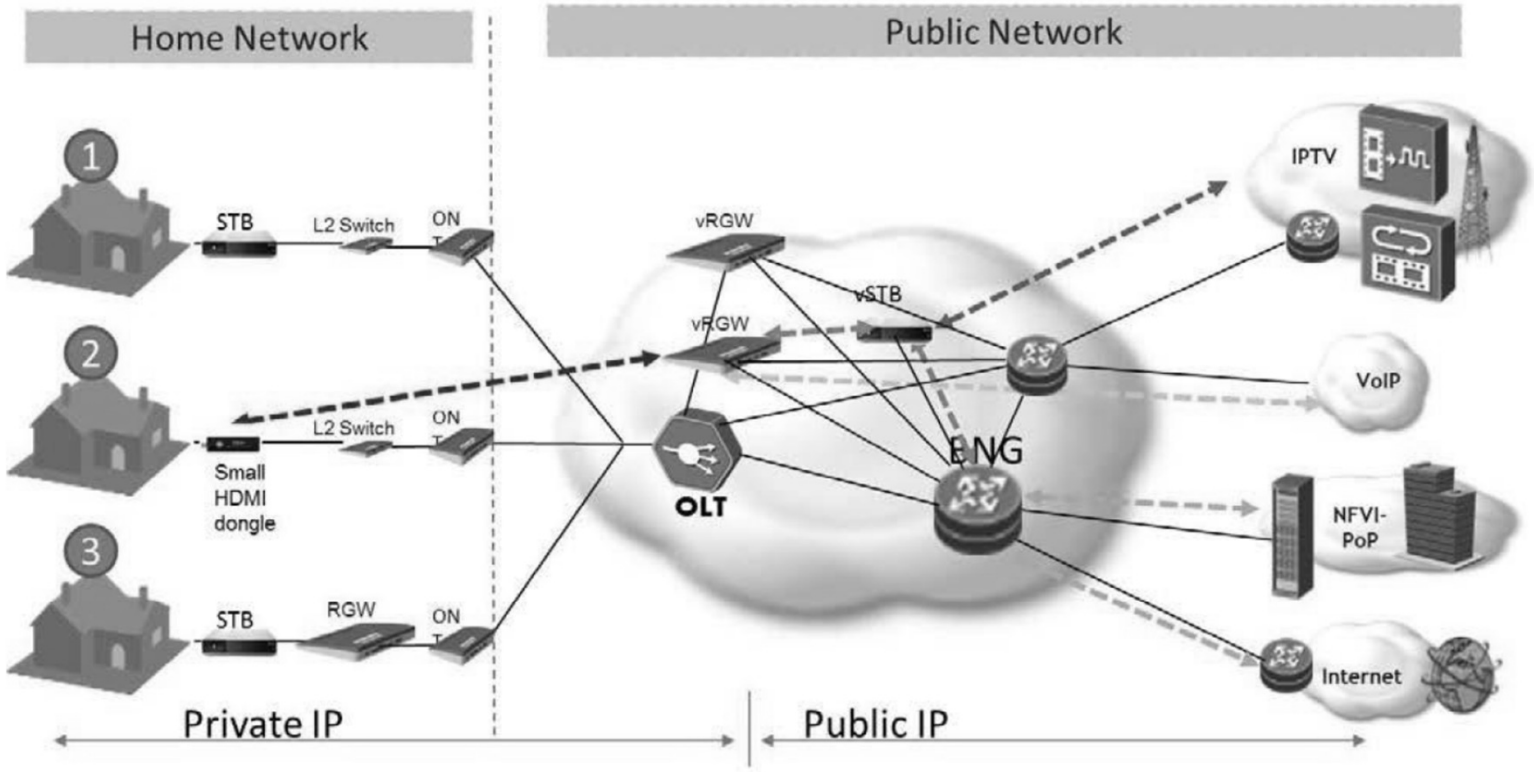


Figure 23: Home Virtualisation - Both RGW and STB are Virtualised - Public IP

Use Case 2: CPE again (Ref. 3) Home setting

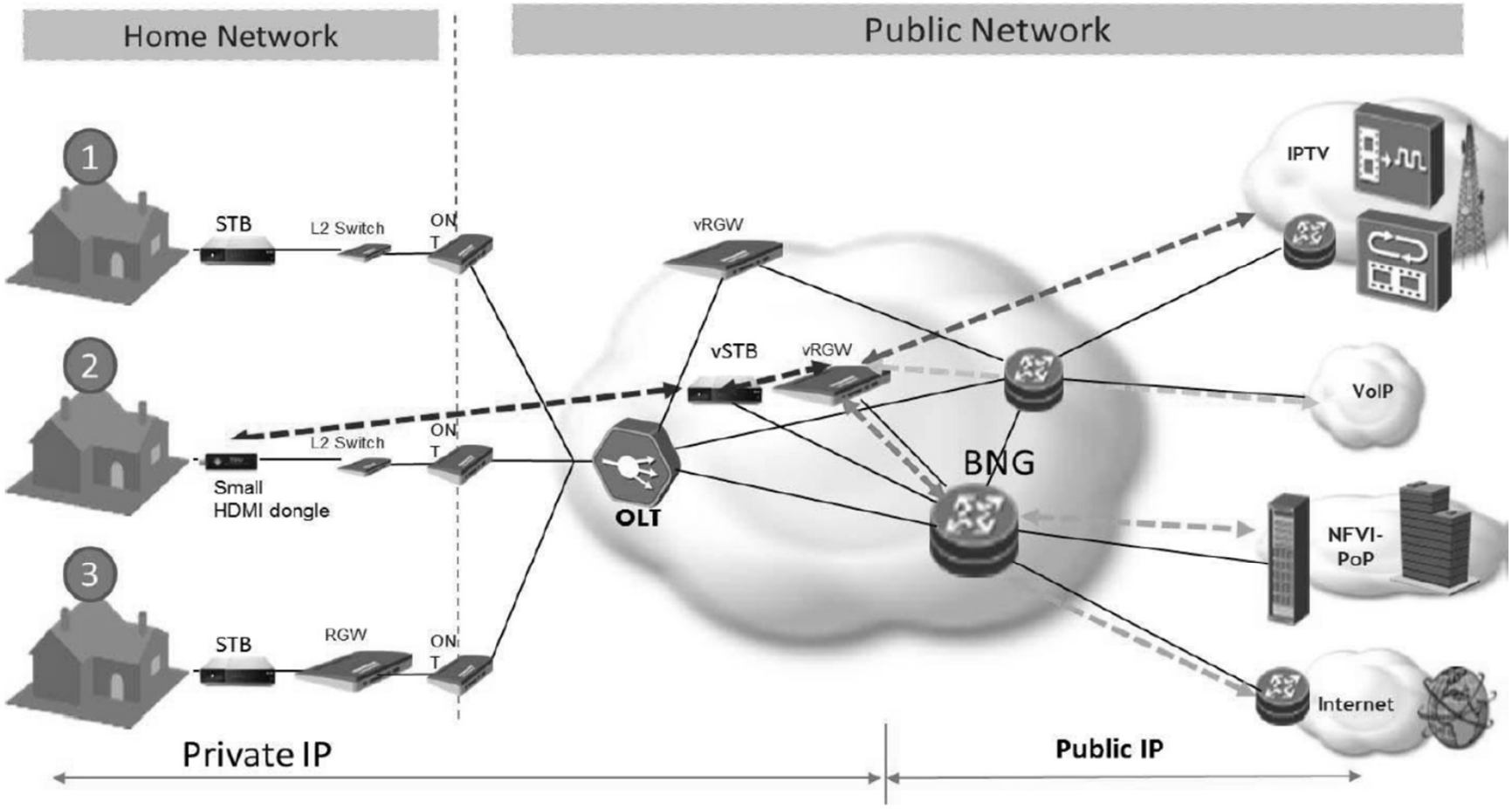
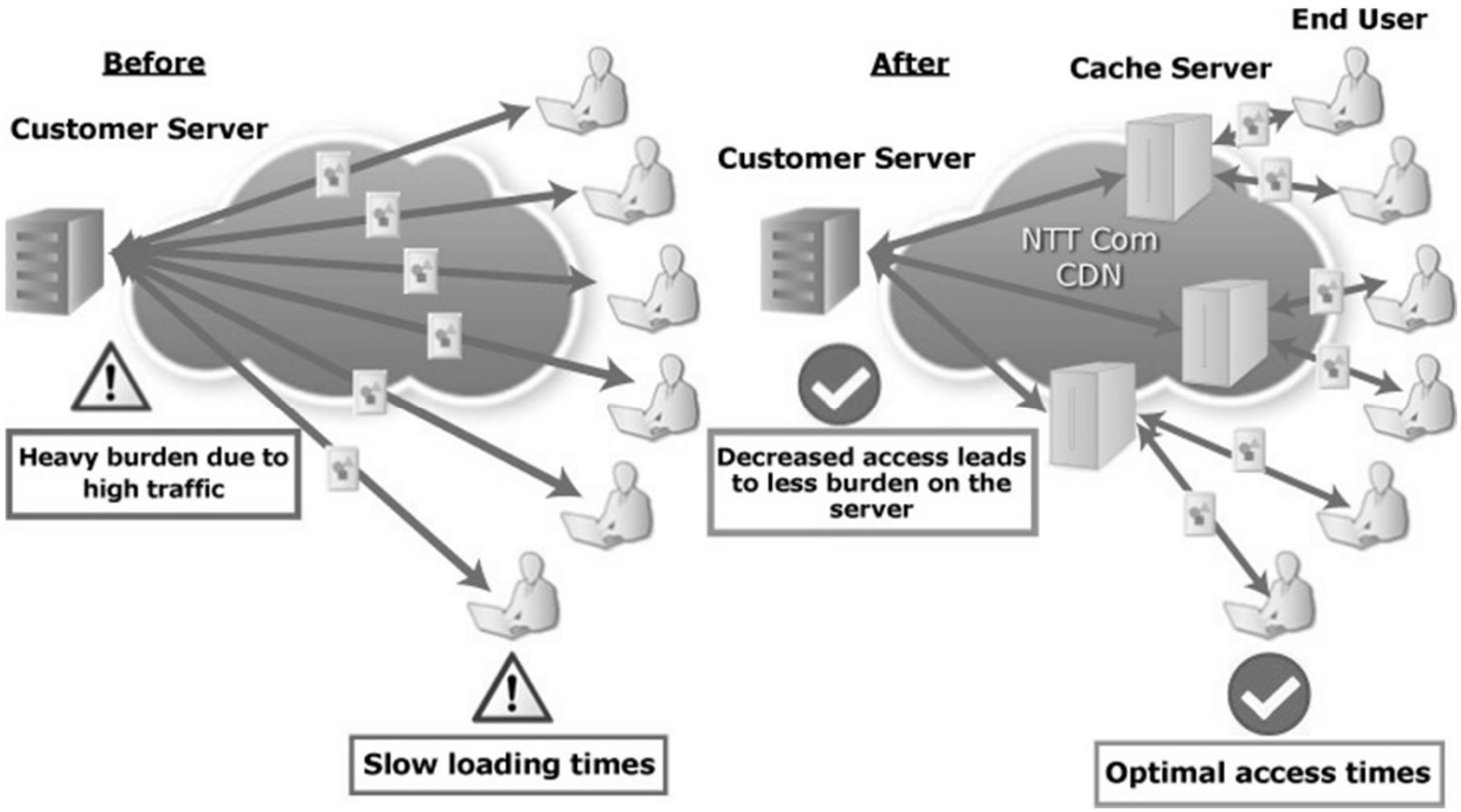
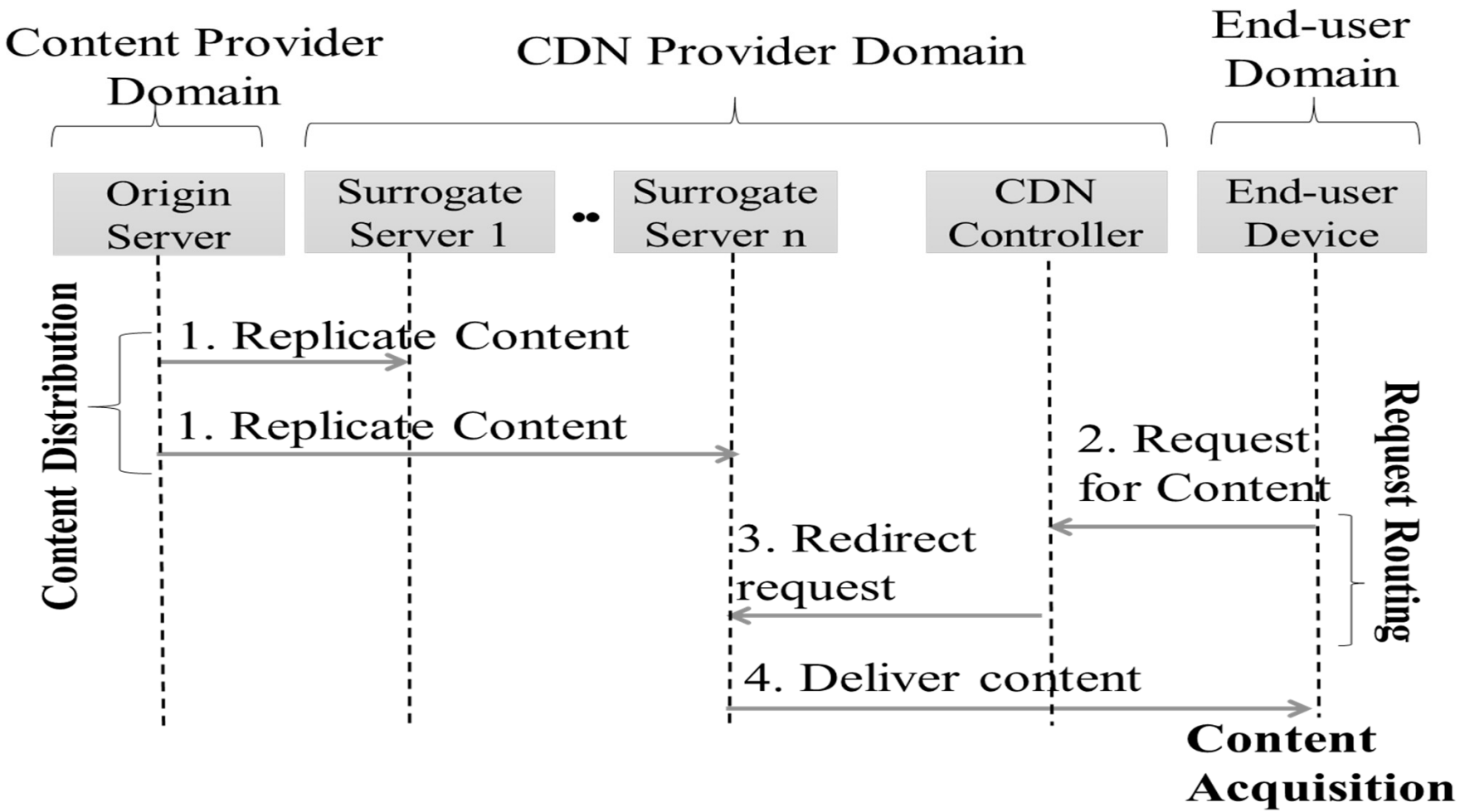


Figure 24: Home Virtualisation - Both RGW and STB are Virtualised in Private IP

Use Case 3: Content Delivery Networks



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)

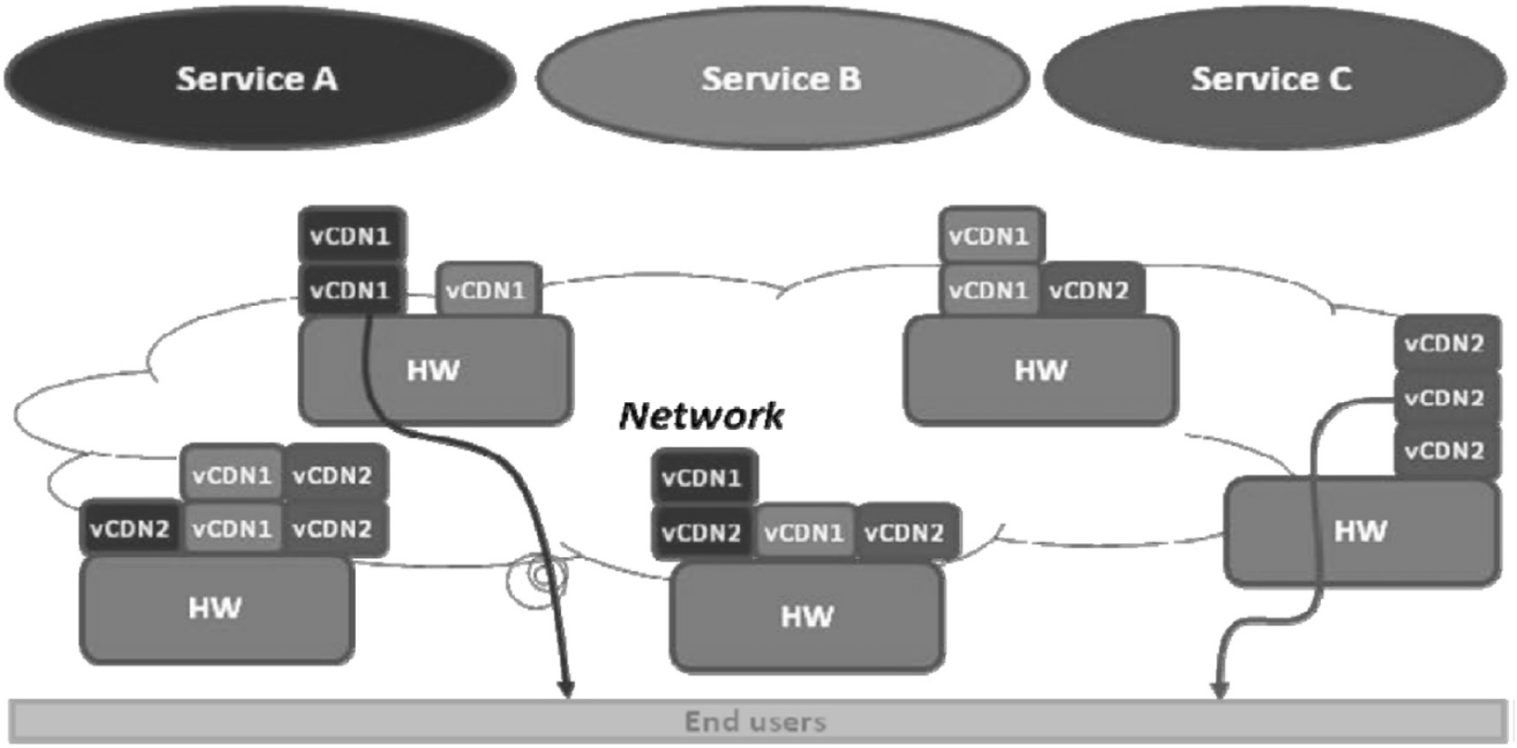
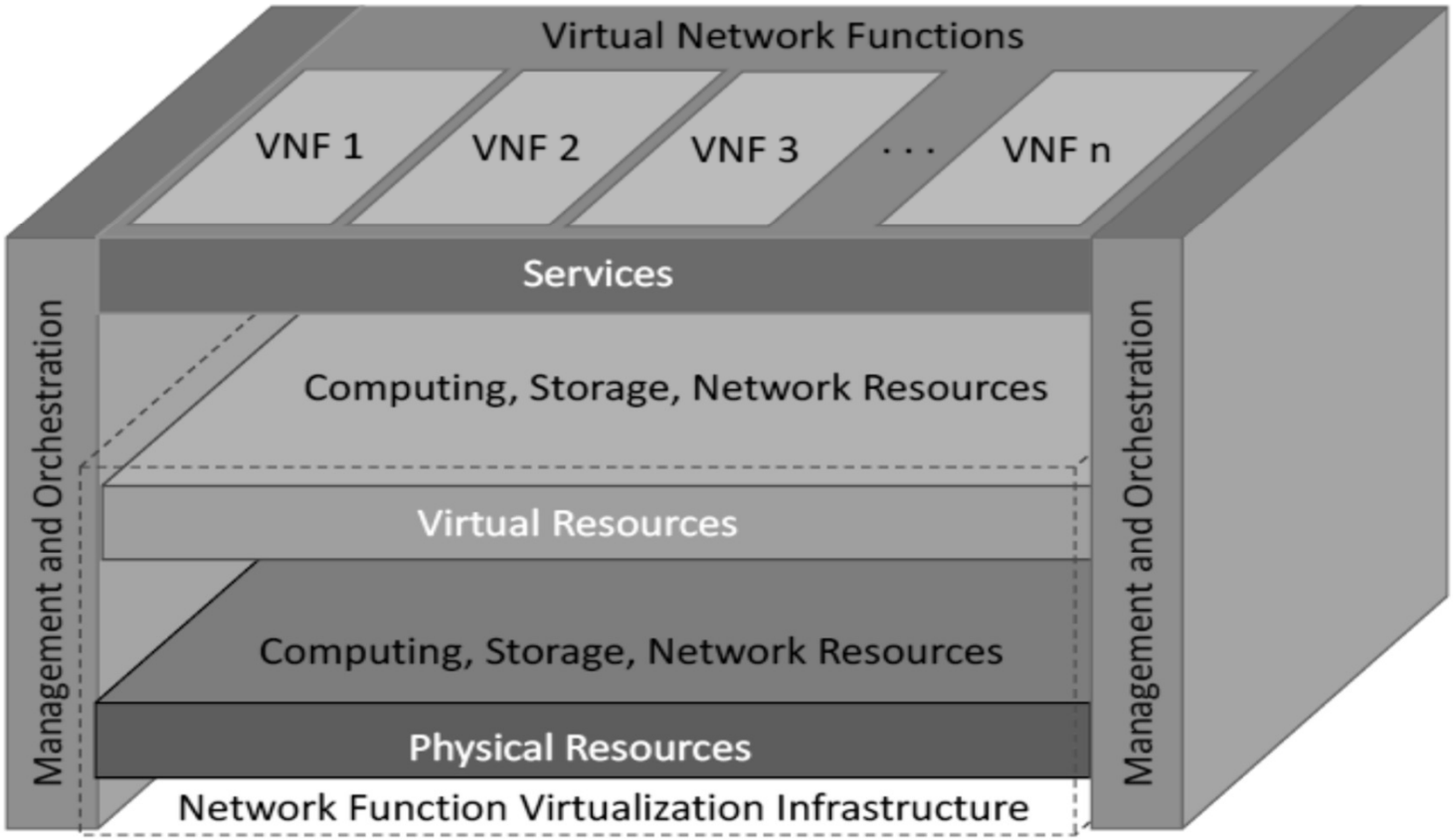


Figure 26: principle of different vCDN cache nodes deployment in Virtualised environment

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

Architecture

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

Architecture

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

Business Model

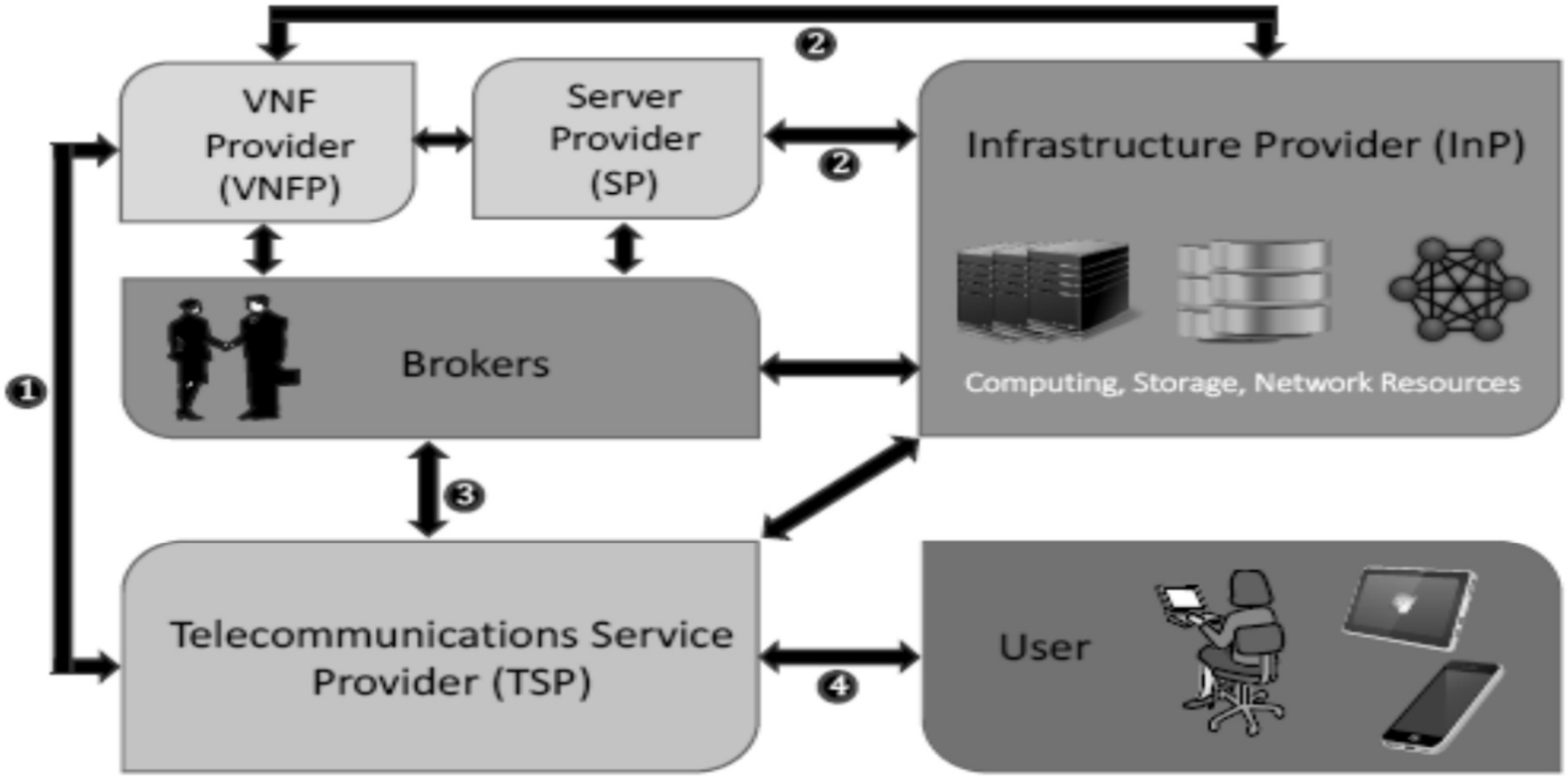


Fig. 5. Proposed NFV Business Model

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.

Business Model (Ref. 1)

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)

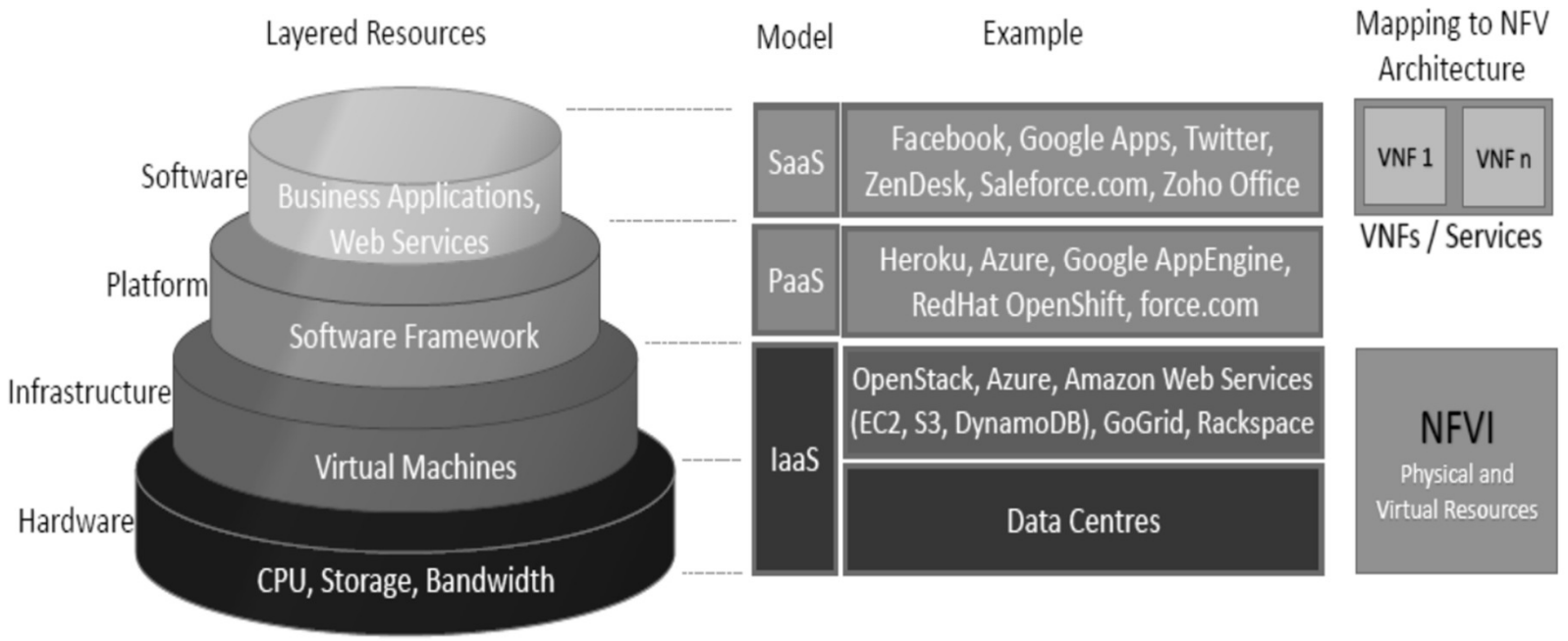


Fig. 6. Cloud Computing Service Models and their Mapping to Part of the NFV Reference Architecture

TABLE I
COMPARISON OF NFV IN TELECOMMUNICATION NETWORKS AND CLOUD COMPUTING

NFV, Cloud and SDN (Ref. 1)

TABLE I
COMPARISON OF NFV IN TELECOMMUNICATION NETWORKS AND CLOUD COMPUTING

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

NFV, Cloud and SDN (Ref. 1)

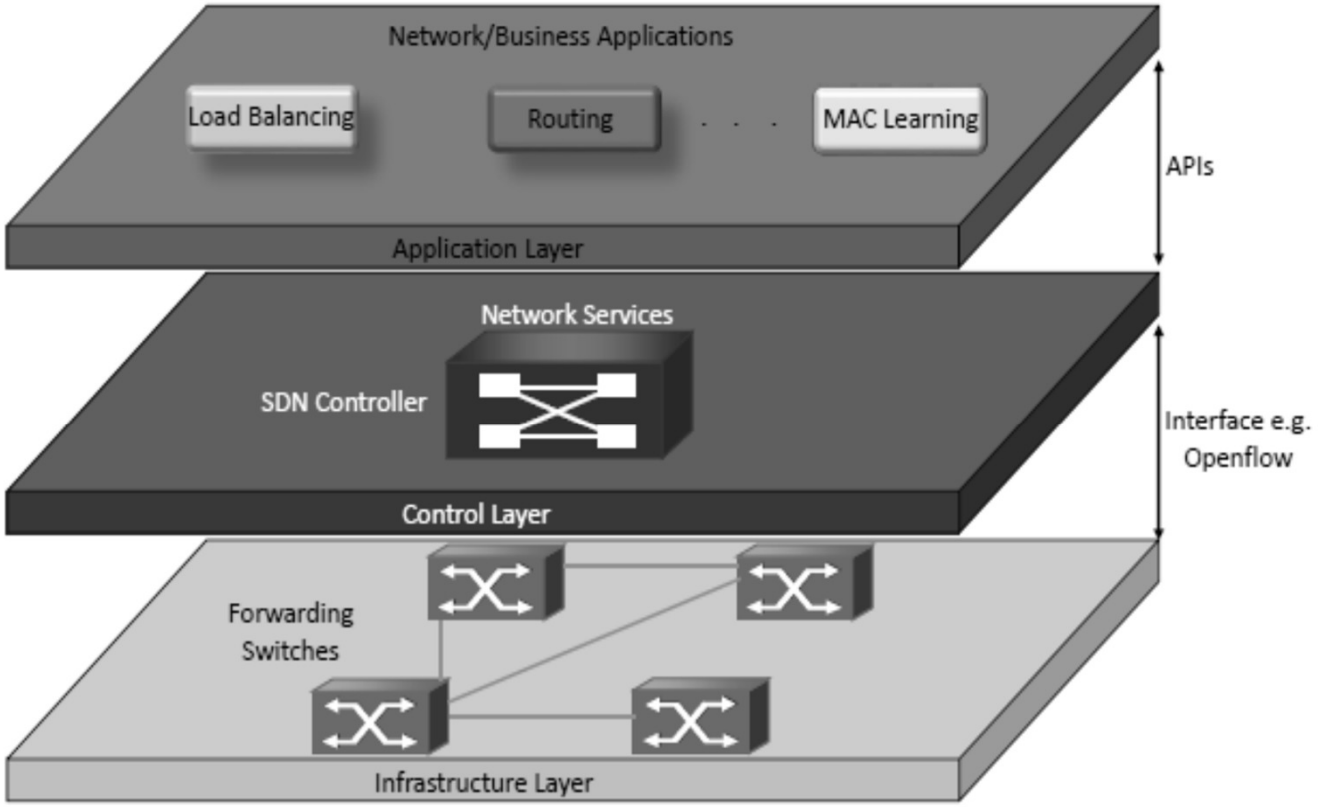


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Fig. 8. Logical Layers in a Software Defined Network

NFV, Cloud and SDN (Ref. 1)

TABLE II
COMPARISON OF SOFTWARE DEFINED NETWORKING AND NETWORK FUNCTION VIRTUALIZATION CONCEPTS

Issue	NFV (Telecom Networks)	Software Defined Networking
Approach	Service/Function Abstraction	Networking Abstraction
Formalization	ETSI	ONF
Advantage	Promises to bring flexibility and cost reduction	Promises to bring unified programmable control and open interfaces
Protocol	Multiple control protocols (e.g SNMP, NETCONF)	OpenFlow is de-facto standard
Applications run	Commodity servers and switches	Commodity servers for control plane and possibility for specialized hardware for data plane
Leaders	Mainly Telecom service providers	Mainly networking software and hardware vendors
Business Initiator	Telecom service providers	Born on the campus, matured in the data center

NFV, Cloud and SDN (Ref. 1)

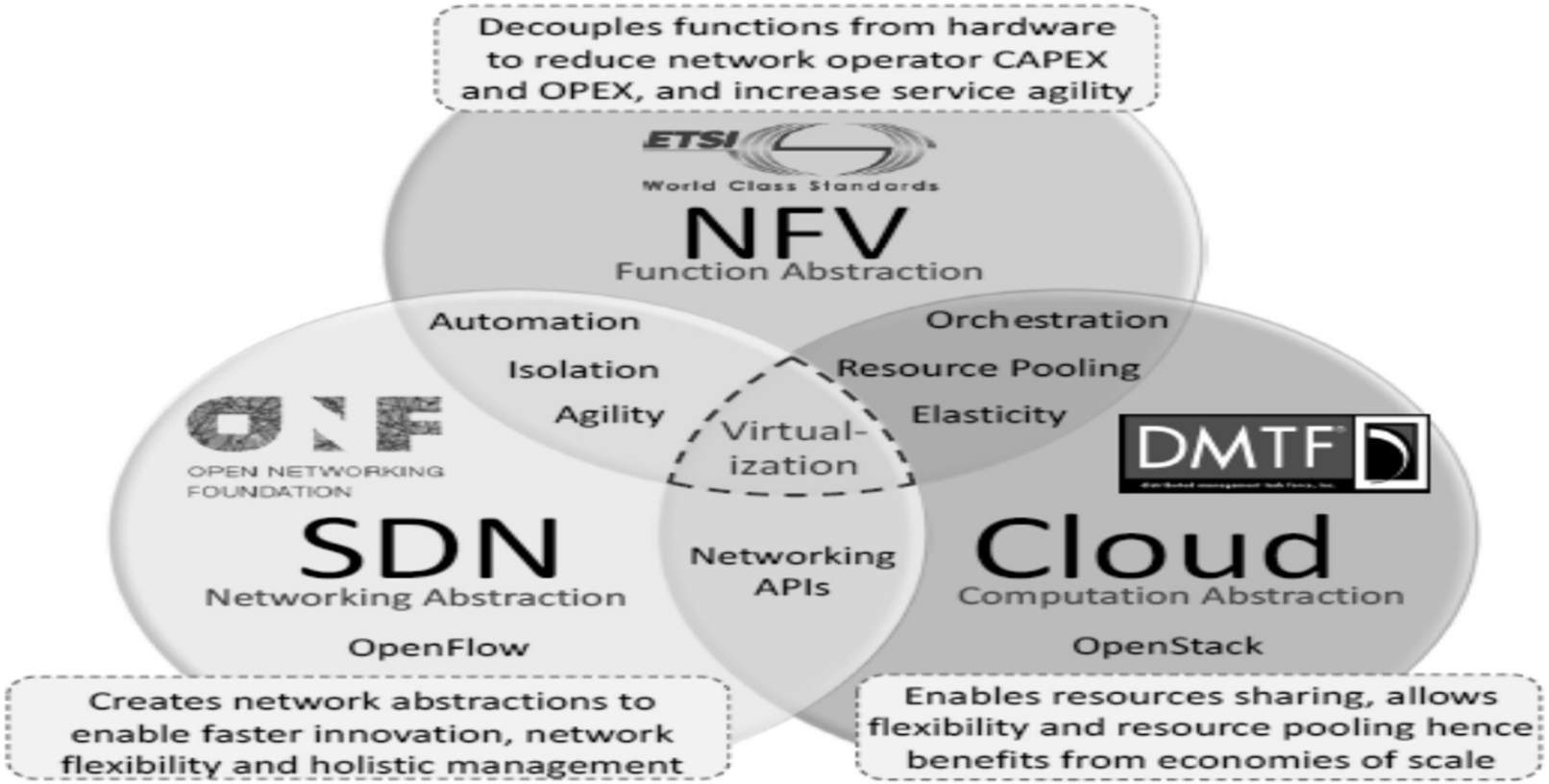

Fig. 9. Relationship between NFV, SDN & Cloud Computing

The End