Skoltech
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SDN&NFV:
Network Function Virtualization (NFV)

Advanced Computer Networks

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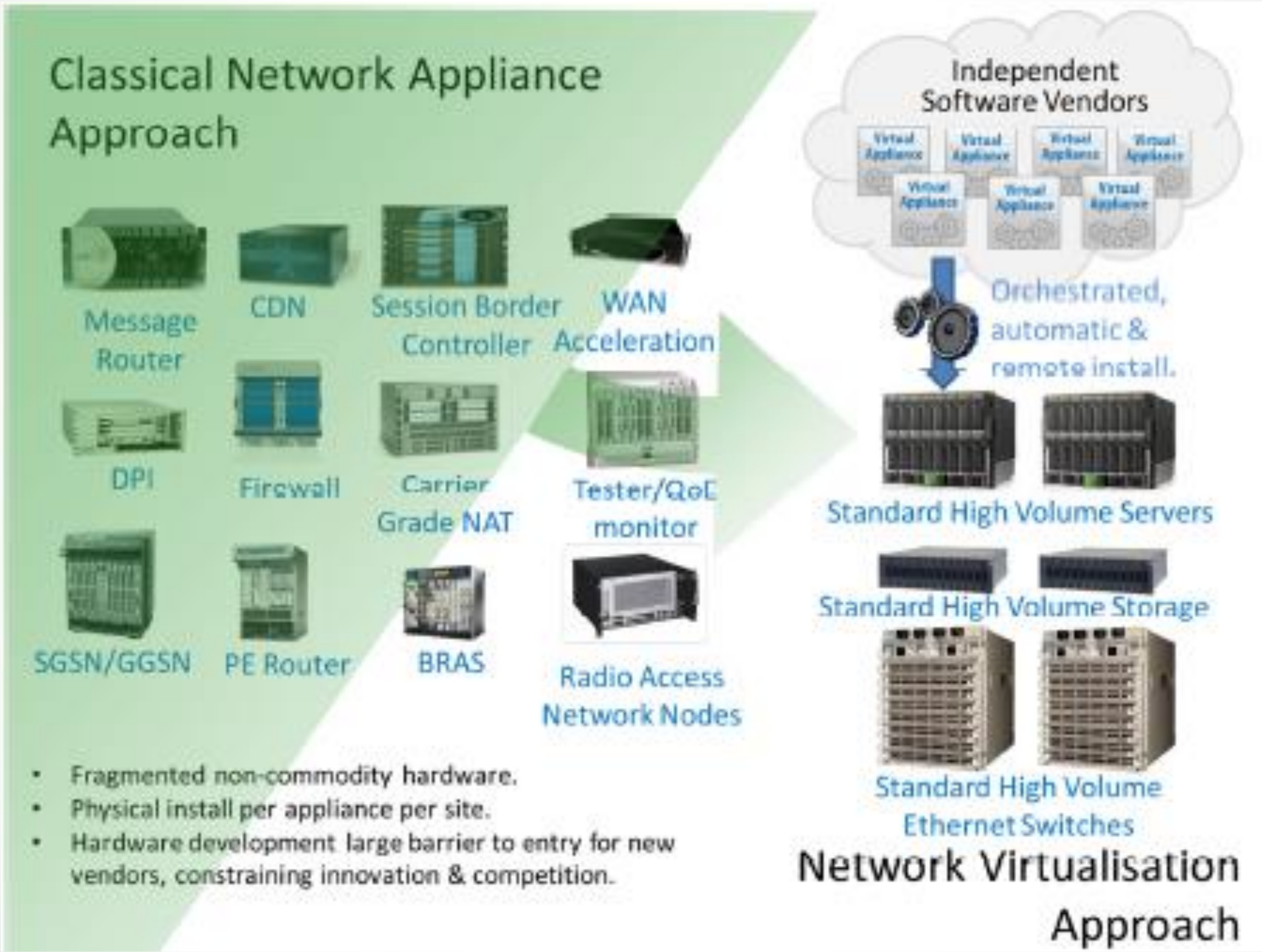
Part I: Introduction to Network Function Virtualization (NFV)

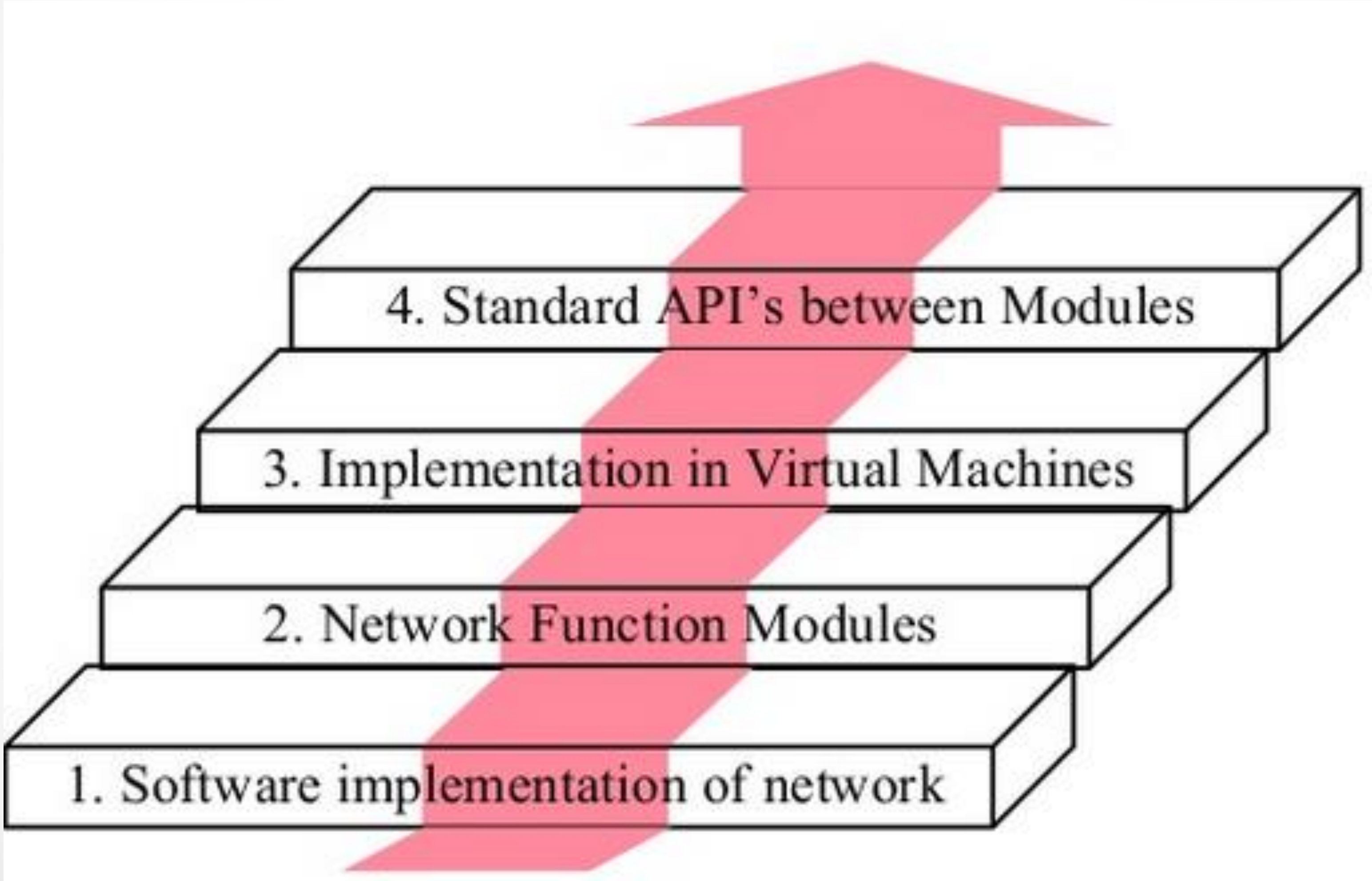
Problems of Telecom Operators

- Network traffic is growing
- More network hardware are required (CAPEX)
- Income is not growing
- Infrastructure consists of proprietary expensive network equipment.
- Static resource allocation.
- The implementation of a new network services takes up to 18 months.

Virtual Network Services

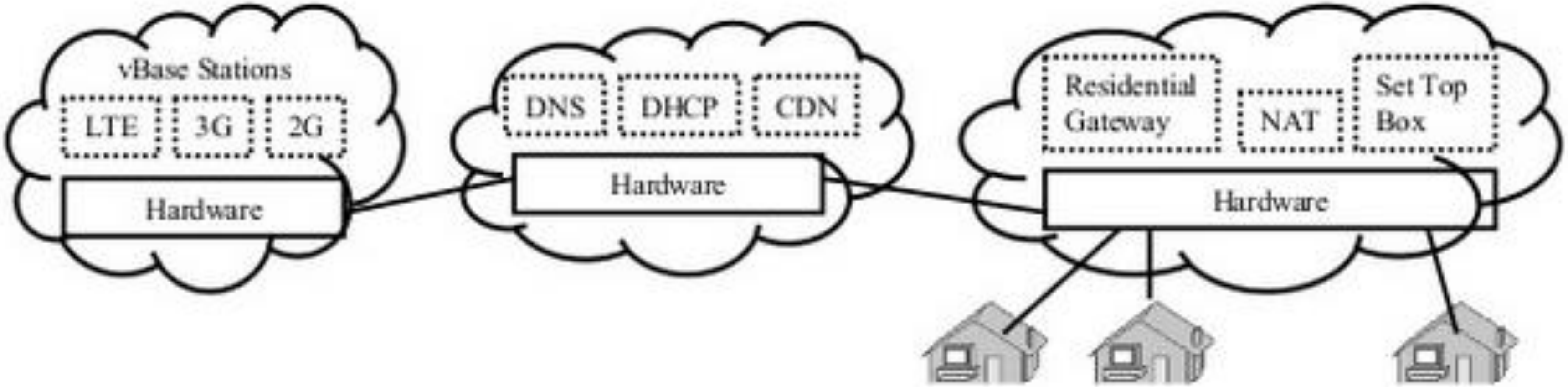


NFV Evolution Levels



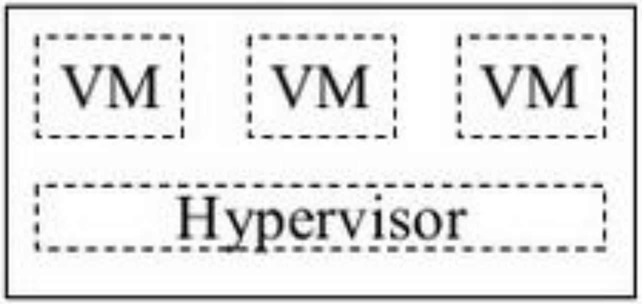
NFV Evolution

1. Fast standard hardware ⇒ **Software based Devices**
   Routers, Firewalls, Broadband Remote Access Server (BRAS)
   ⇒ A.k.a. *white box* implementation
2. **Function Modules** (Both data plane and control plane)
   ⇒ DHCP (Dynamic Host control Protocol), NAT (Network Address Translation), Rate Limiting,



NFV Evolution

3. **Virtual Machine implementation**
   ⇒ Virtual appliances
   ⇒ All advantages of virtualization (quick provisioning, scalability, mobility, Reduced CapEx, Reduced OpEx, …)



4. **Standard APIs**: New ISG (Industry Specification Group) in ETSI (European Telecom Standards Institute) set up in November 2012

NFV Benefits

NFV is porting network functions to virtual machines:

- Simplify the deployment and upgrade of both software and hardware
- Cost reduction through the use of standard servers
- Grouping services

Examples

BRAS

- User Session Termination
- Interested in the benefit per user ~ 1Mbps
- The cost of existing solutions is approximately 10k for 10Gbps => One connection = $ 1
- With NFV: one server can handle 50Gbps. Cost $ 5k => **One connection = $ 0.1.**

- CG-NAT
  – Address Translation
  – The high cost of existing solutions.
  – You save: **$ 16 -> $ 4 -> $ 2 per connection**

Architecture (ETSI)

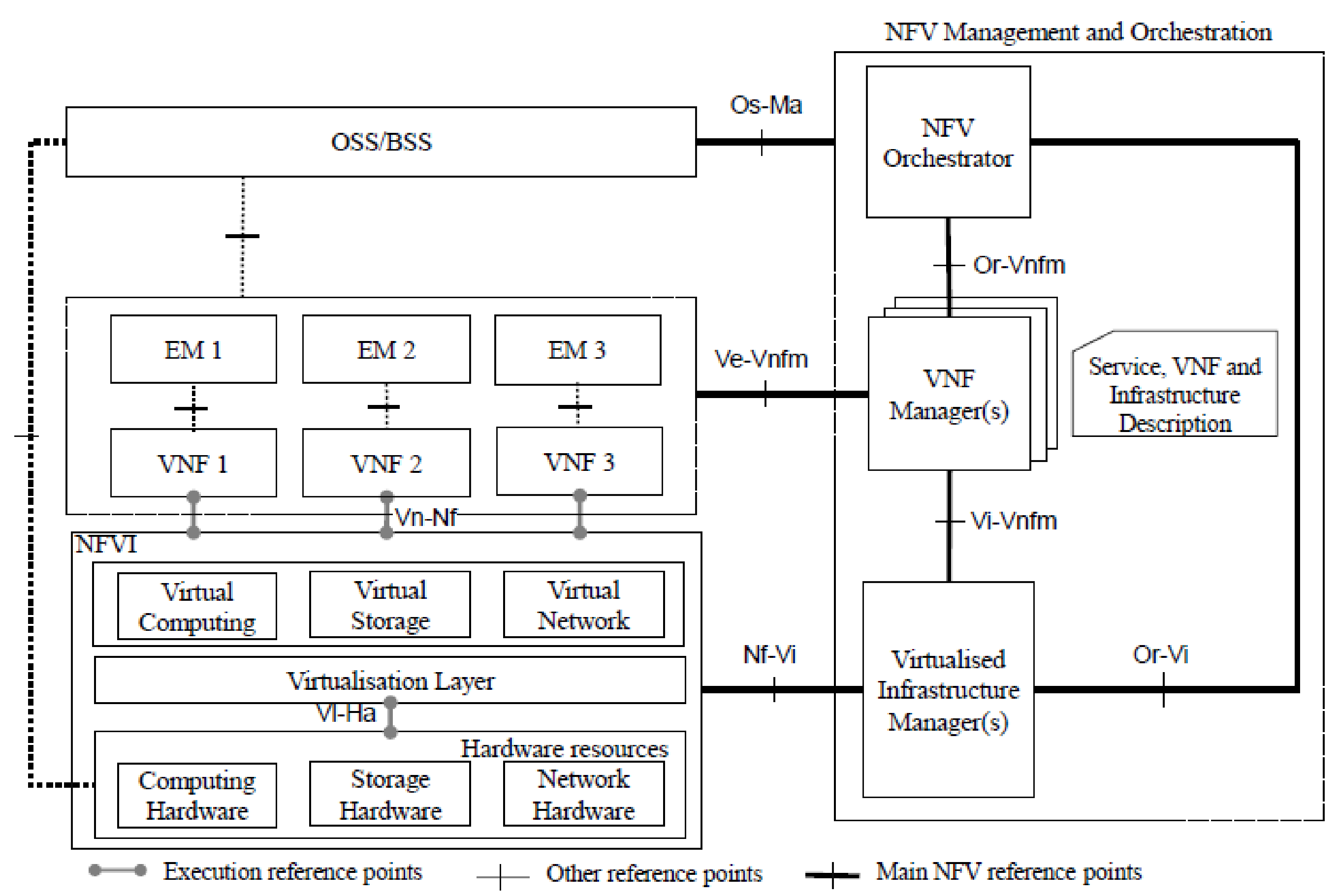


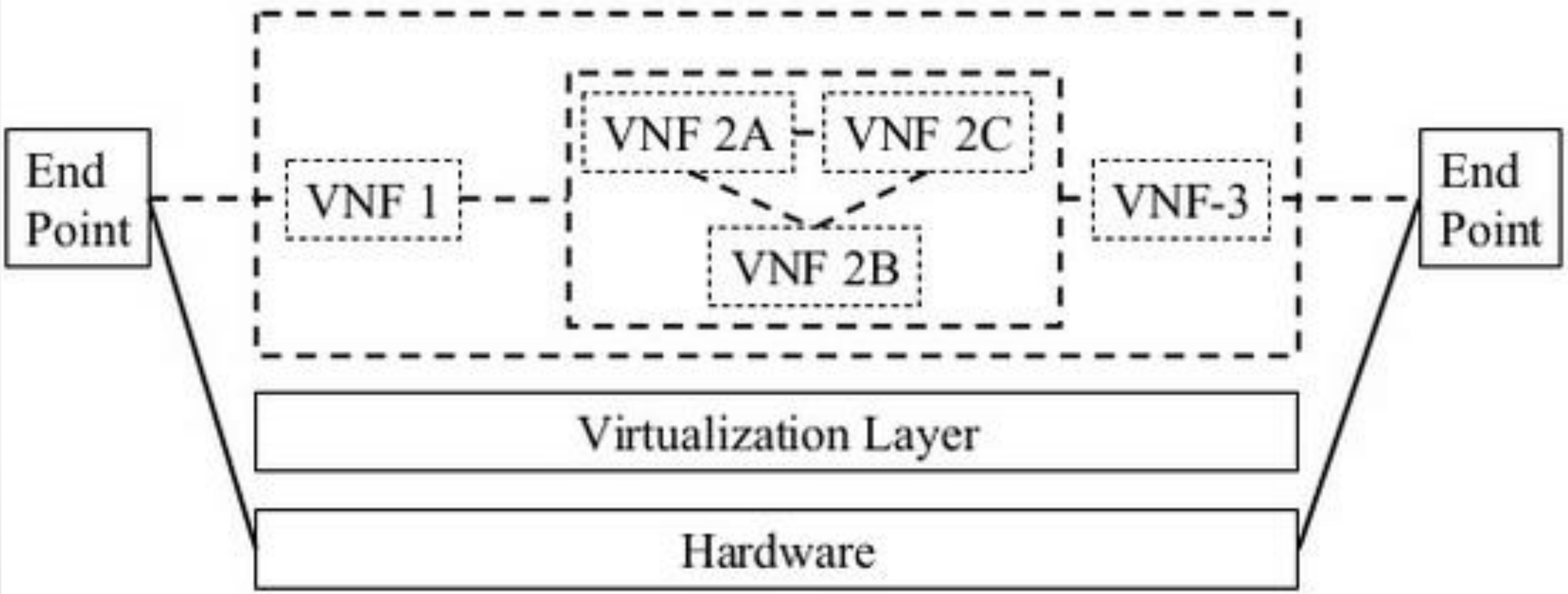
Figure 4: NFV reference architectural framework

Basic Concepts

- **Network Function (NF):** Functional building block with a well defined interfaces and well defined functional behavior
- **Virtualized Network Function (VNF)**: Software implementation of NF that can be deployed in a virtualized infrastructure
- **VNF Set**: Connectivity between VNFs is not specified, e.g., residential gateways
- **VNF Forwarding Graph**: Service chain when network connectivity order is important, e.g., firewall, NAT, load balancer
- **NFV Infrastructure (NFVI)**: Hardware and software required to deploy, mange and execute VNFs including computation, networking, and storage.

Network Forwarding Graph

- An end-to-end service may include nested forwarding graphs



Basic Concepts (2)

- **NFVI Point of Presence (PoP)**: Location of NFVI
- **NFVI-PoP Network**: Internal network
- **Transport Network**: Network connecting a PoP to other PoPs or external networks
- **VNF Manager**: VNF lifecycle management e.g., instantiation, update, scaling, query, monitoring, fault diagnosis, healing, termination
- **Virtualized Infrastructure Manager**: Management of computing, storage, network, software resources
- **Network Service**: A composition of network functions and defined by its functional and behavioral specification
- **NFV Service**: A network services using NFs with at least one VNF.

Basic Concepts (3)

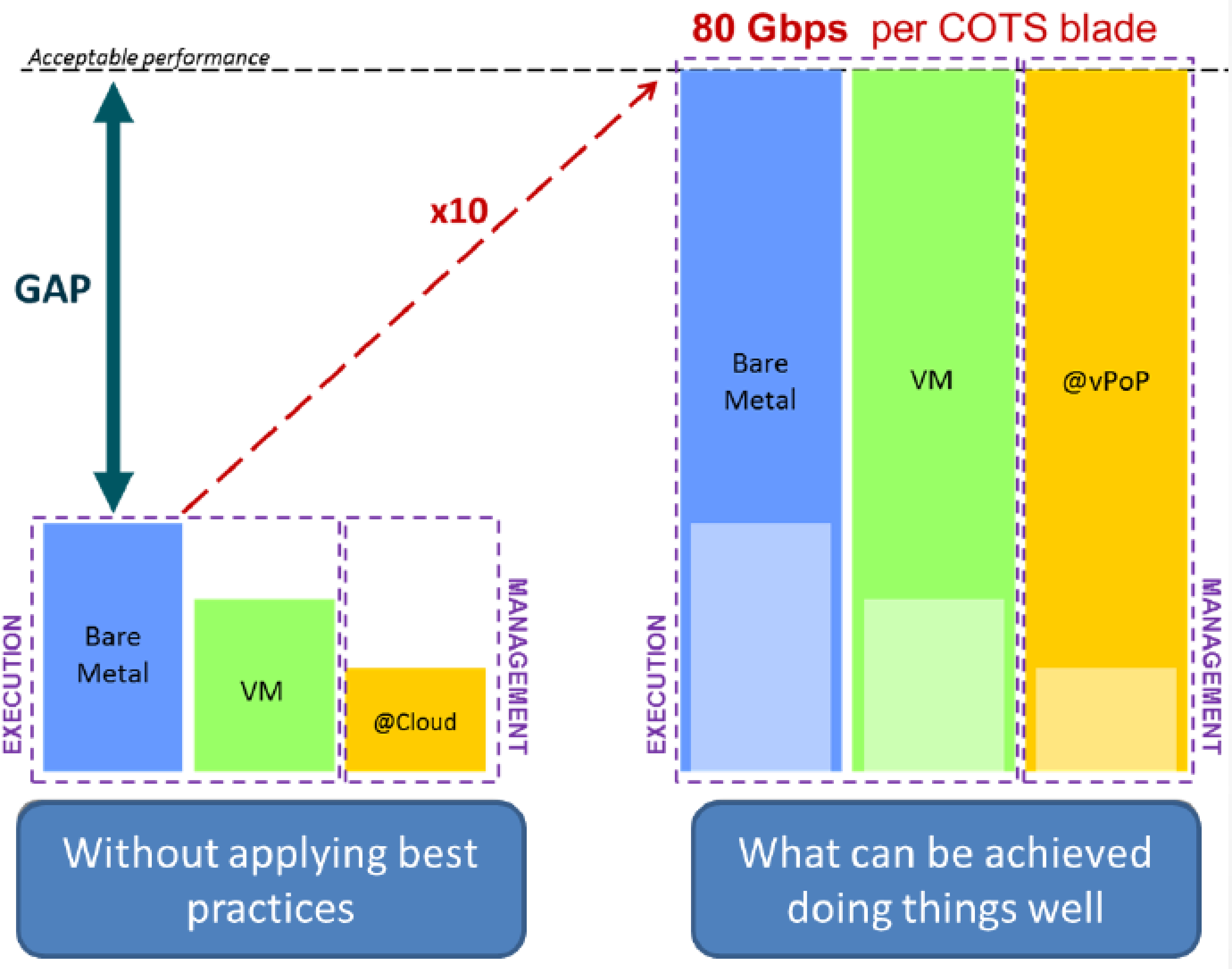
- **User Service**: Services offered to end users/customers/subscribers.
- **Deployment Behavior**: NFVI resources that a VNF requires, e.g., Number of VMs, memory, disk, images, bandwidth, latency
- **Operational Behavior**: VNF instance topology and lifecycle operations, e.g., start, stop, pause, migration, …
- **VNF Descriptor**: Deployment behavior + Operational behavior
- **NFV Orchestrator**: Automates the deployment, operation, management, coordination of VNFs and NFVI.
- **VNF Forwarding Graph**: Connection topology of various NFs of which at least one is a VNF

NFV Use Cases

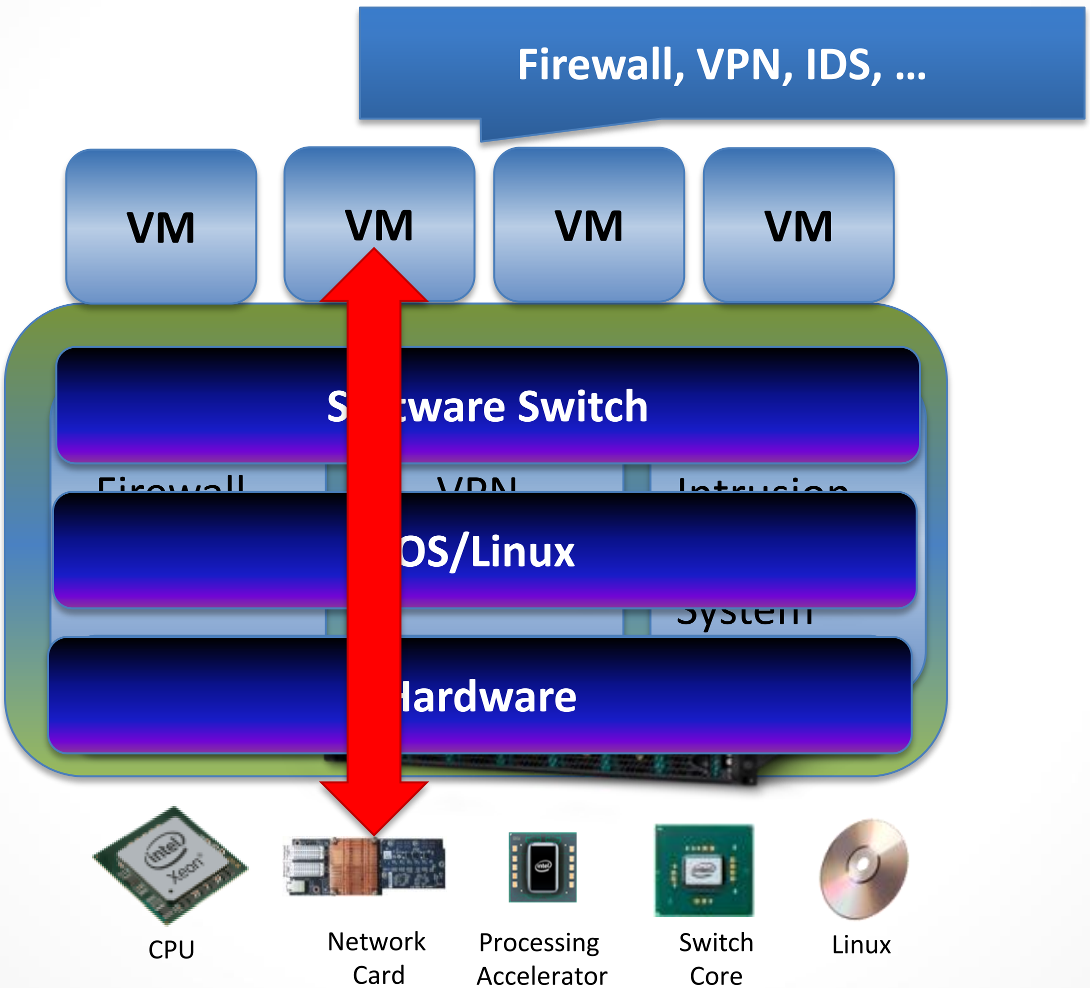
- **Cloud**:
  1. NFV infrastructure as a service (NFVIaaS) like IaaS
  2. Virtual Network Functions (VNFs) as a service (VNFaaS) like SaaS
  3. VNF forwarding graphs (Service Chains)
  4. Virtual Network Platform as a Service (VNPaaS) like PaaS
- **Mobile**:
  5. Virtualization of the Mobile Core Network and IMS
  6. Virtualization of Mobile Base Station
- **Data Center**:
  7. Virtualization of CDNs
- **Access/Residential**:
  8. Virtualization of the Home environment
  9. Fixed Access NFV

Part II: Network Services Performance Issue

Network Services Performance Issue



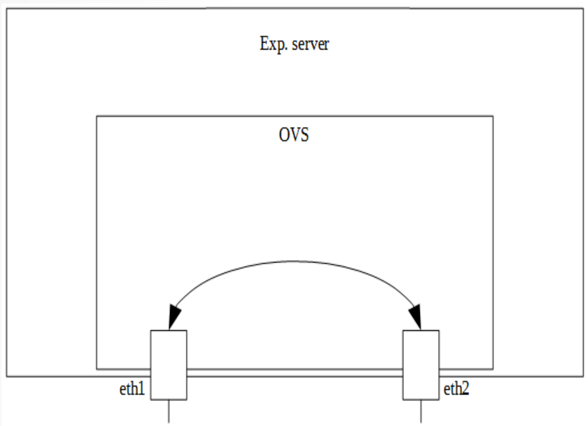
Virtualization Platform Node

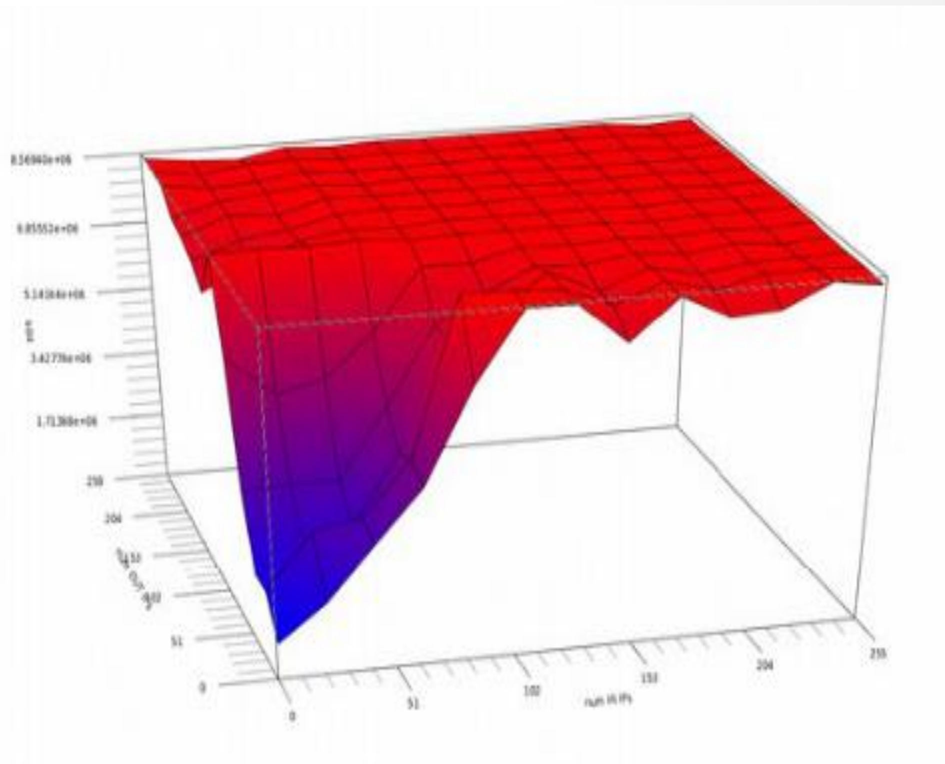


Bottlenecks

- Linux Networking Stack
  - 300Kpps
- Open vSwitch
- VM

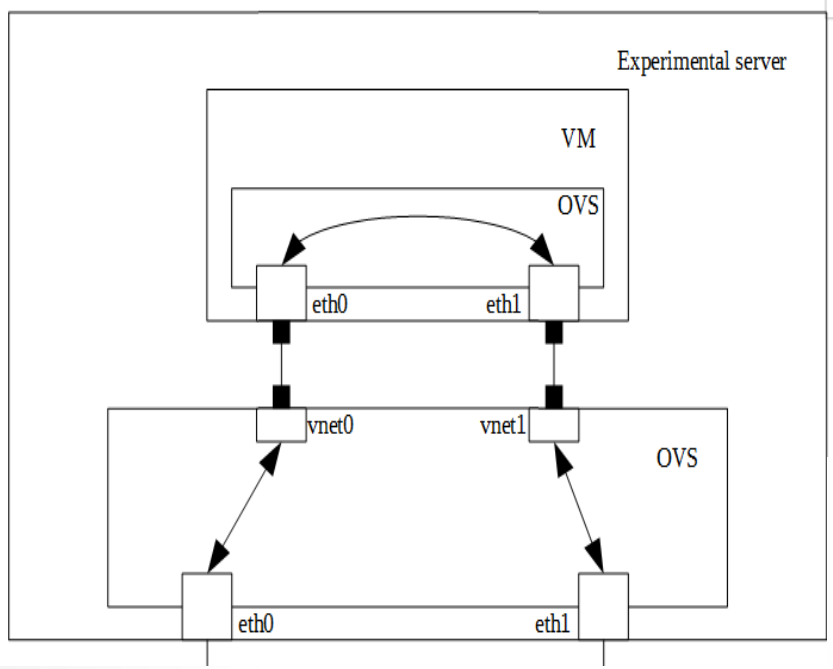
Bottlenecks (OVS)

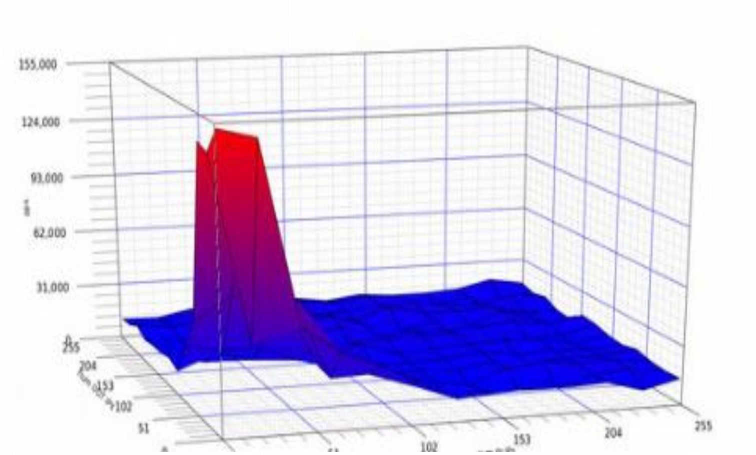


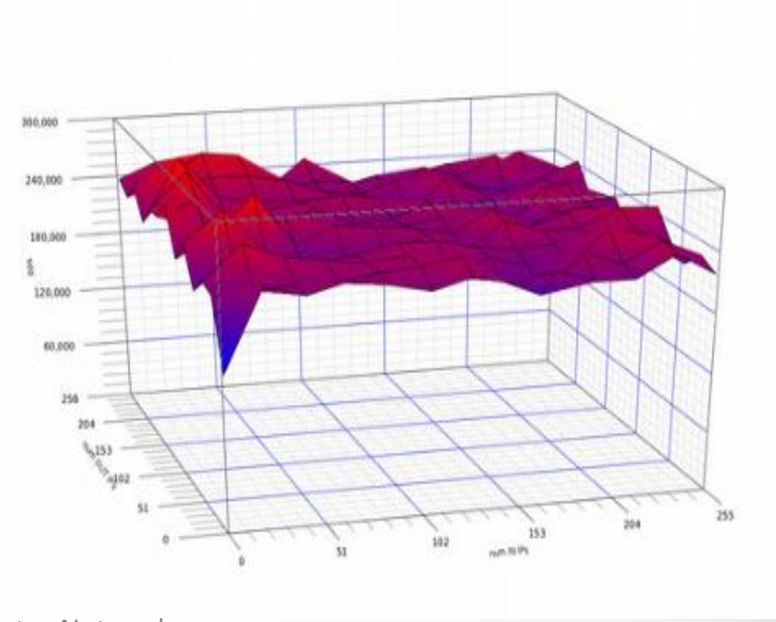


- **Delay:**
  - 11us
- **Throughput:**
  - 1 Mpps

Bottlenecks (KVM)

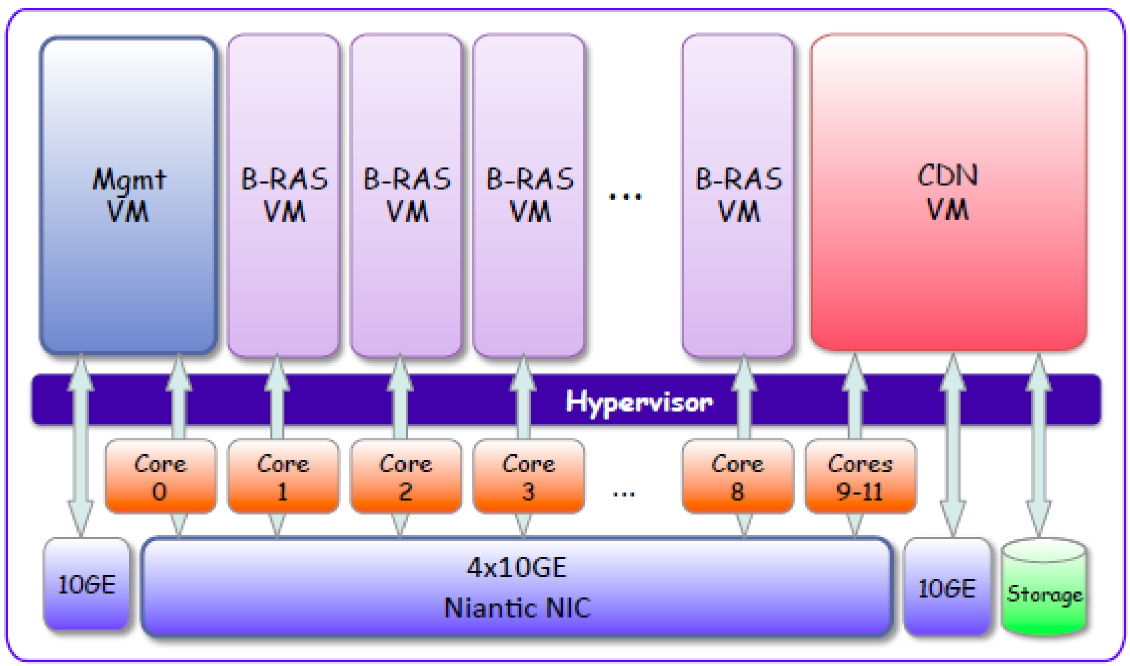






- **Delay:**
  - 300us
- **Throughput:**
  - 20Kpps (kernel OVS)
  - 200Kpps (userspace OVS)

Service Requirements



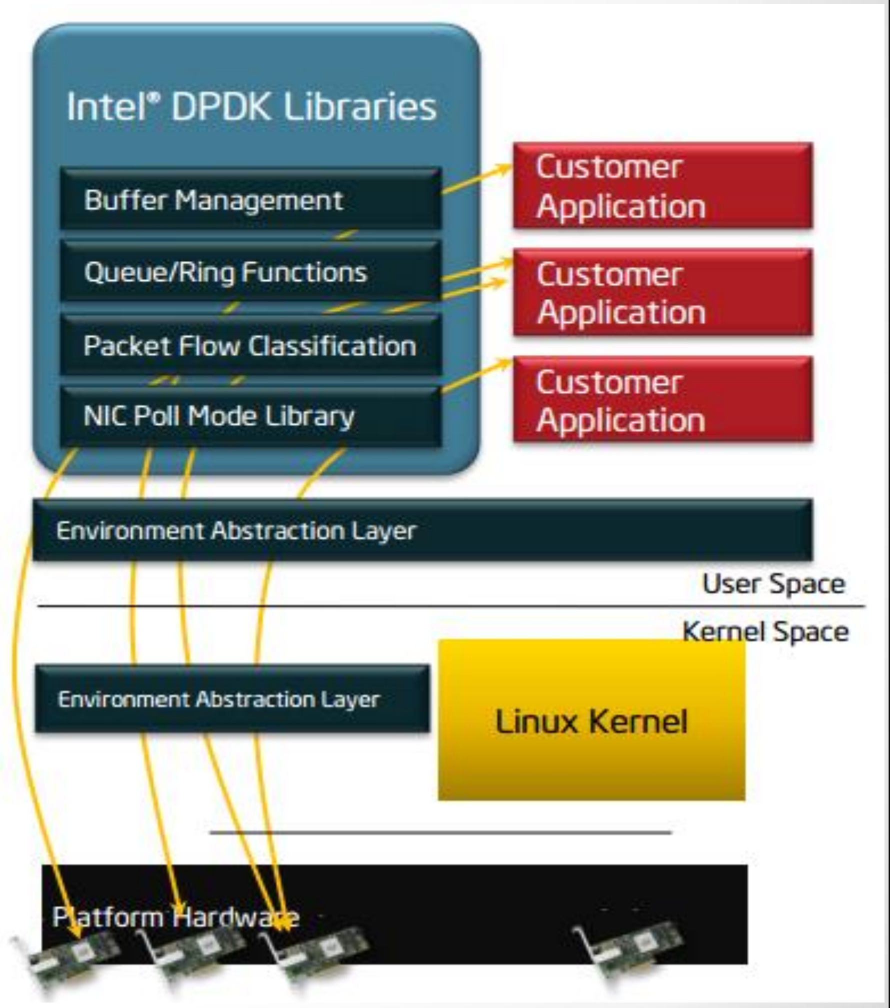
- Ability to bind VM to processor cores
- Scaling a service on a VM using existing processor cores
- The ability to start a service without a VM

Intel DPDK

DPDK = **D**ata **P**lane **D**evelopment **K**it

http://intel.com/go/dpdk/

- Intel DPDK is a set of libraries and drivers for fast packet processing on Intel platforms.
- Using large virtual pages (huge pages 2mb / 1gb).
- The placement of objects evenly across all channels of RAM.
- The address space of the card is accessible from userspace.
- Non-blocking queues for packet transmission.
- No interruptions in DPDK drivers - active loop.
- Active use of SSE instructions for processing packets.
- Allocation of entire processor cores for tasks.

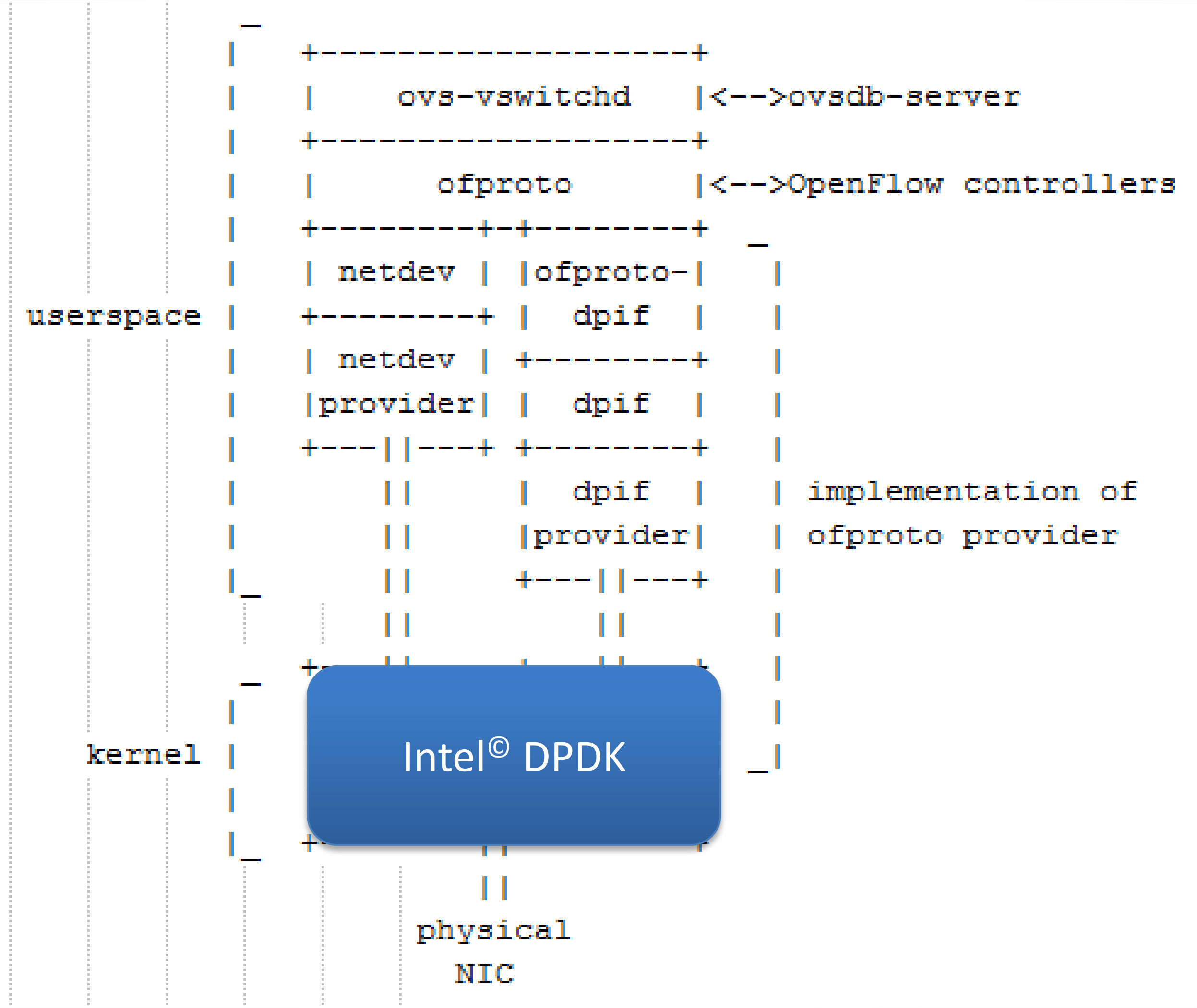


OPEN vSWITCH

An Open Virtual Switch

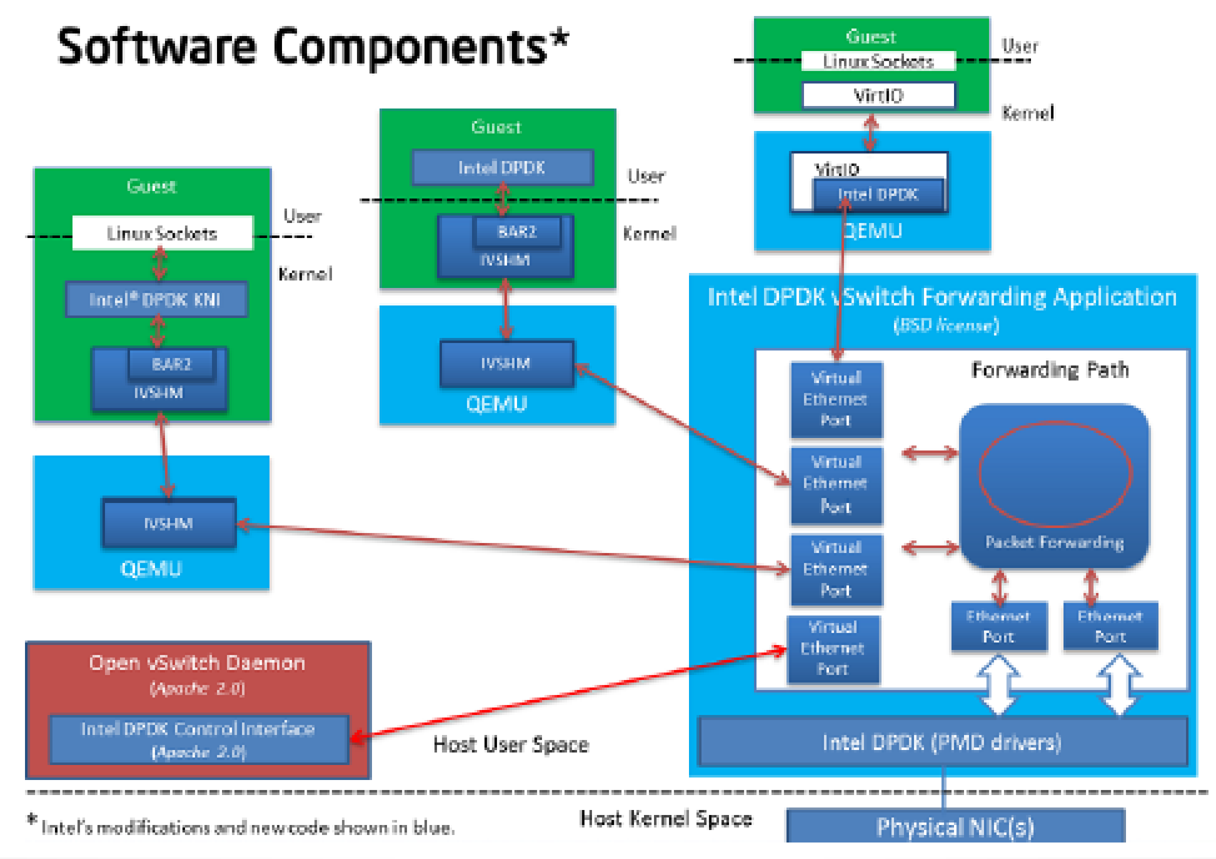
- Open vSwitch - is a virtual software switch that provides connectivity between virtual machines and physical interfaces.
- Supports Ethernet switching with VLAN, SPAN, RSPAN, GRE, sFlow, Netflow.
- Supports OpenFlow 1.2, 1.3.

Open vSwitch Architecture



Intel DPDK vSwitch

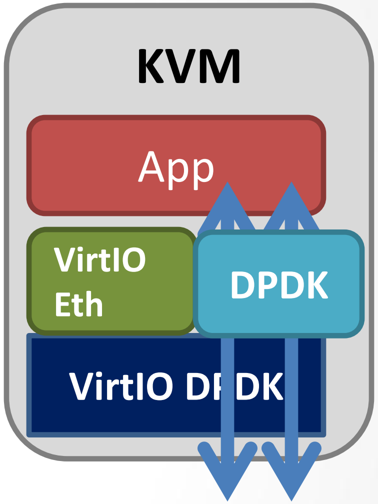
- https://github.com/01org/dpdk-ovs



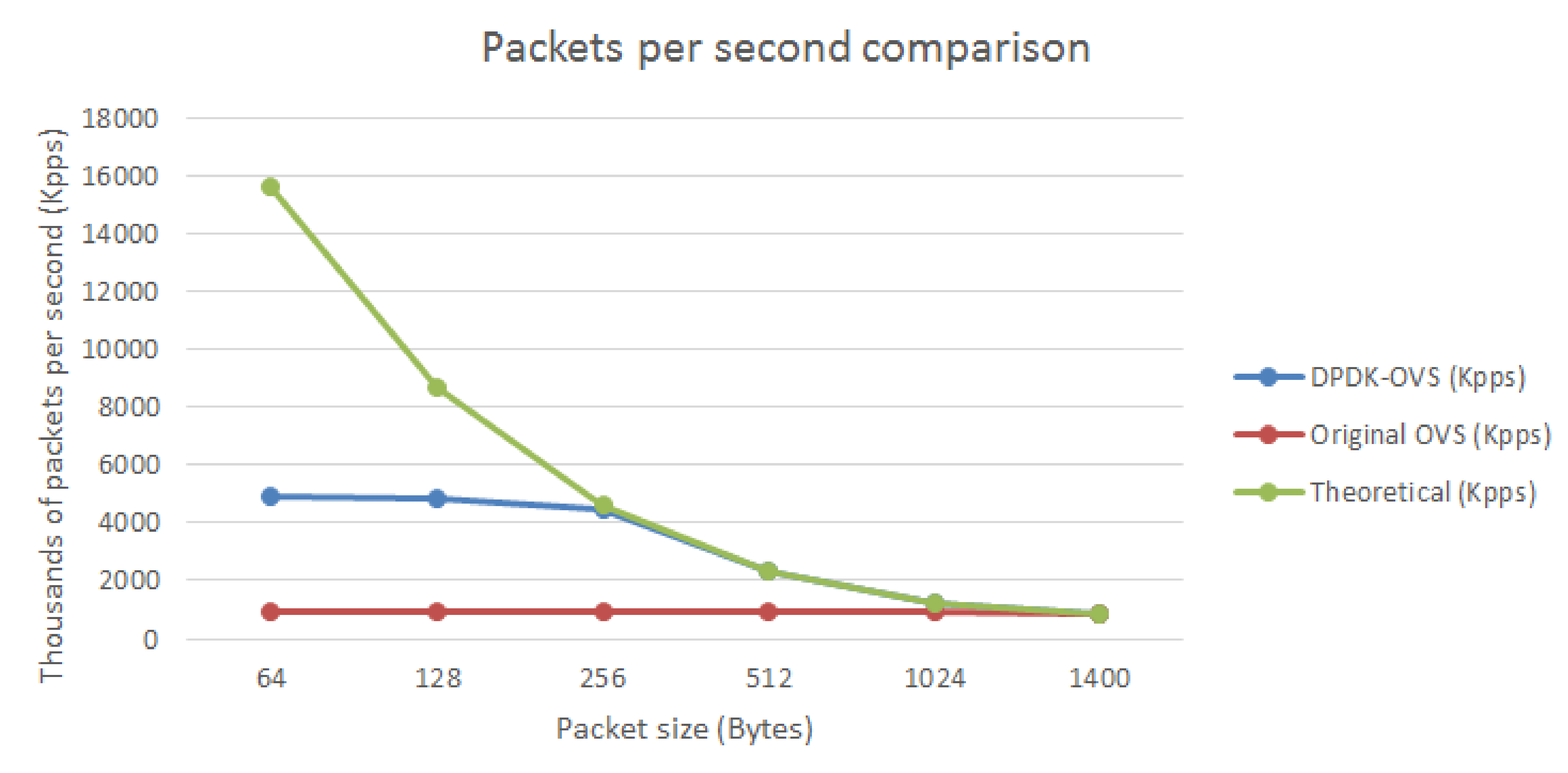
Virtual Machines

Ways of work:

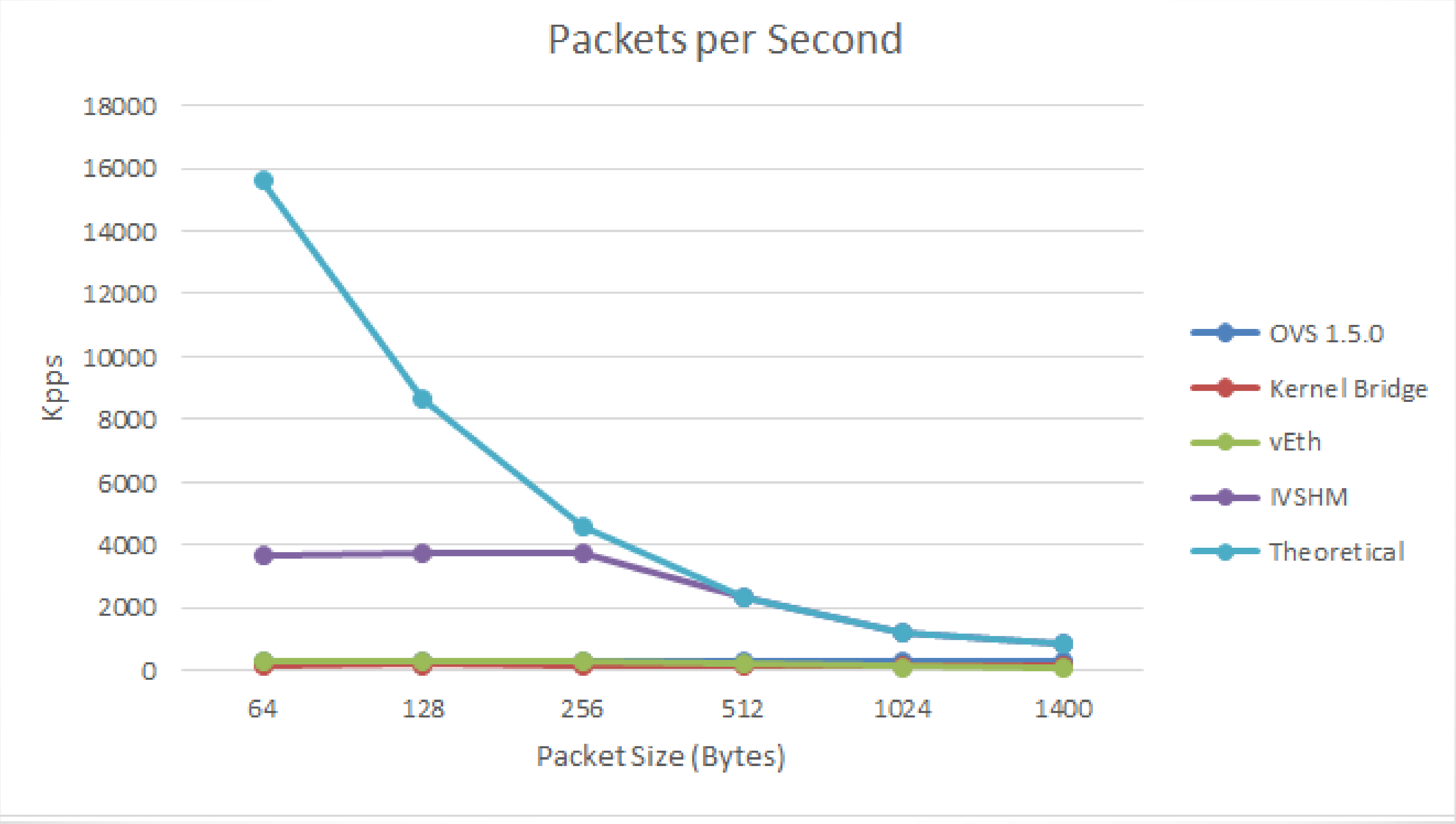
- VIRTIO
  - Transparent for virtual machine applications
  - Slow
- IVSHMEM
  - Highest speed
  - Requires sharpening a service under Intel vSwitch
- Vhost
  - average speed
  - Transparent for DPDK applications



Results: Phy-to-Phy (Kpps)



Results: Phy-to-VM (Kpps)



Part III: NFV+SDN

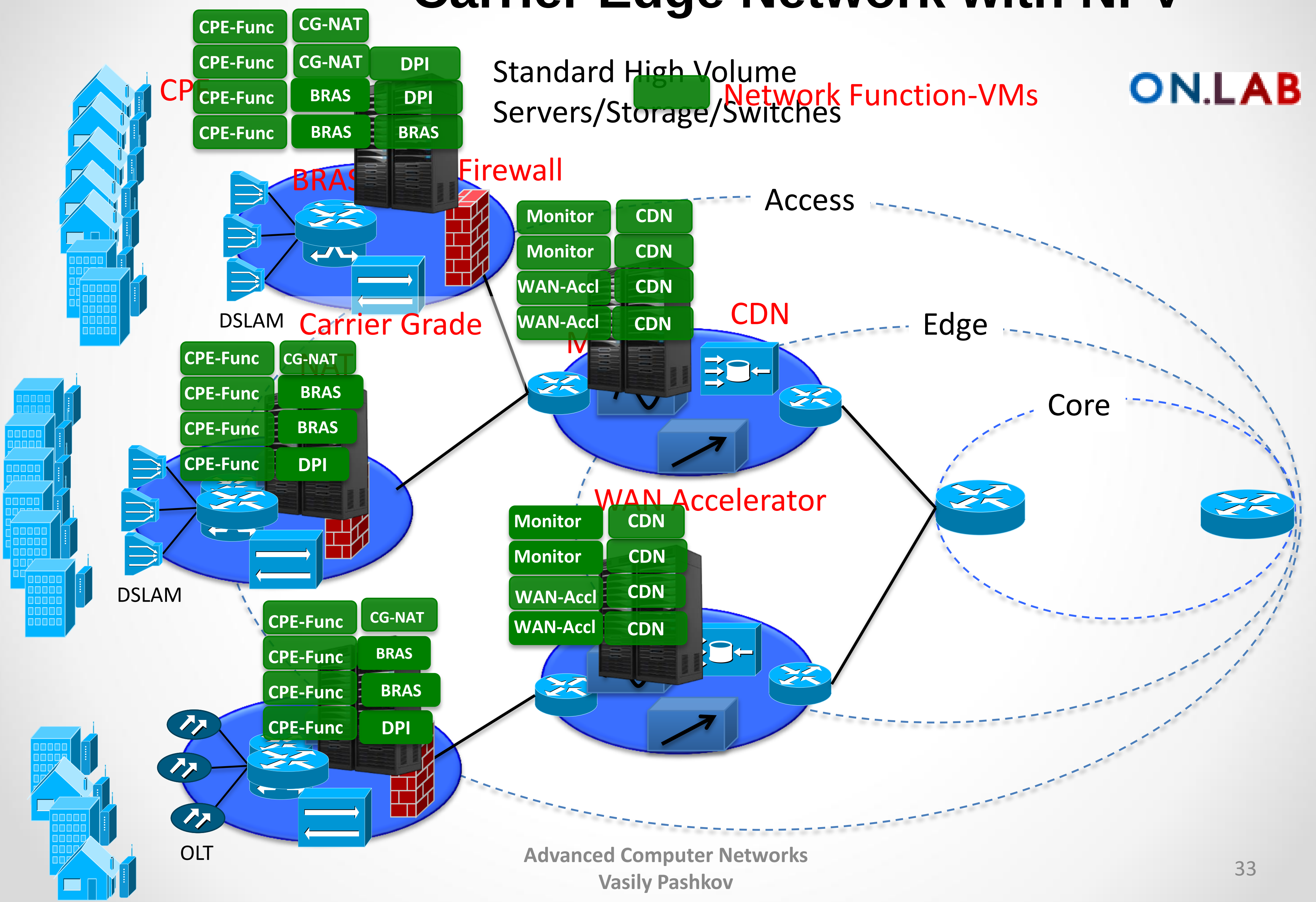
SDN vs NFV

- Concept of NFV originated from SDN
  ⇒ First ETSI white paper showed overlapping Venn diagram
  ⇒ It was removed in the second version of the white paper
- NFV and SDN are complementary.
  One does not depend upon the other.
  You can do SDN only, NFV only, or SDN and NFV.
- Both have similar goals but approaches are very different.
- SDN needs new interfaces, control modules, applications.
  NFV requires moving network applications from dedicated hardware to virtual containers on commercial-off-the-shelf (COTS) hardware
- NFV is present. SDN is the future.
- Virtualization alone provides many of the required features
- Not much debate about NFV.

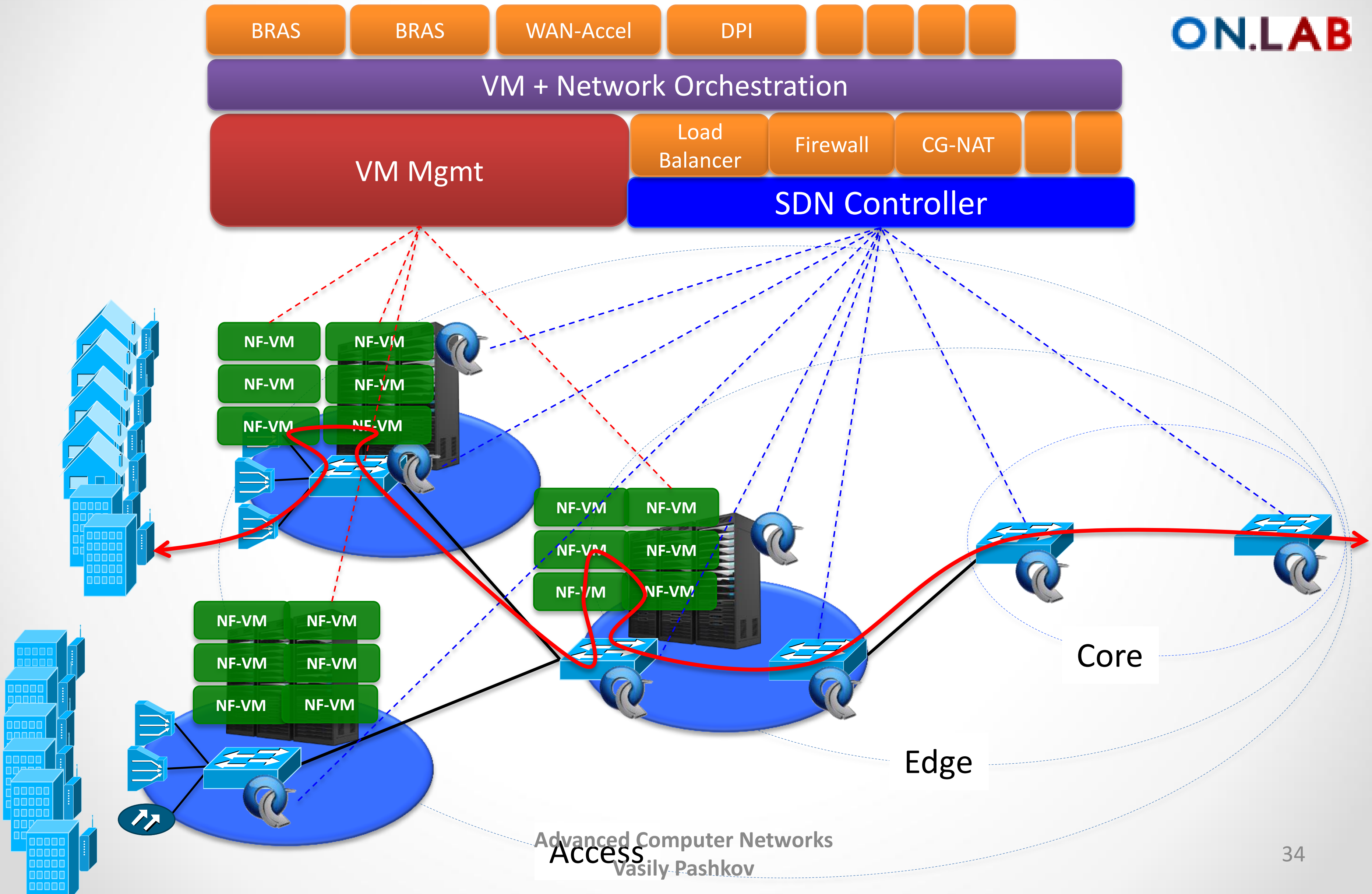
Main Goals

- Orchestration
  - +planning
- Service Chaining
  - Acl->fw->dhcp->lb

Carrier Edge Network with NFV

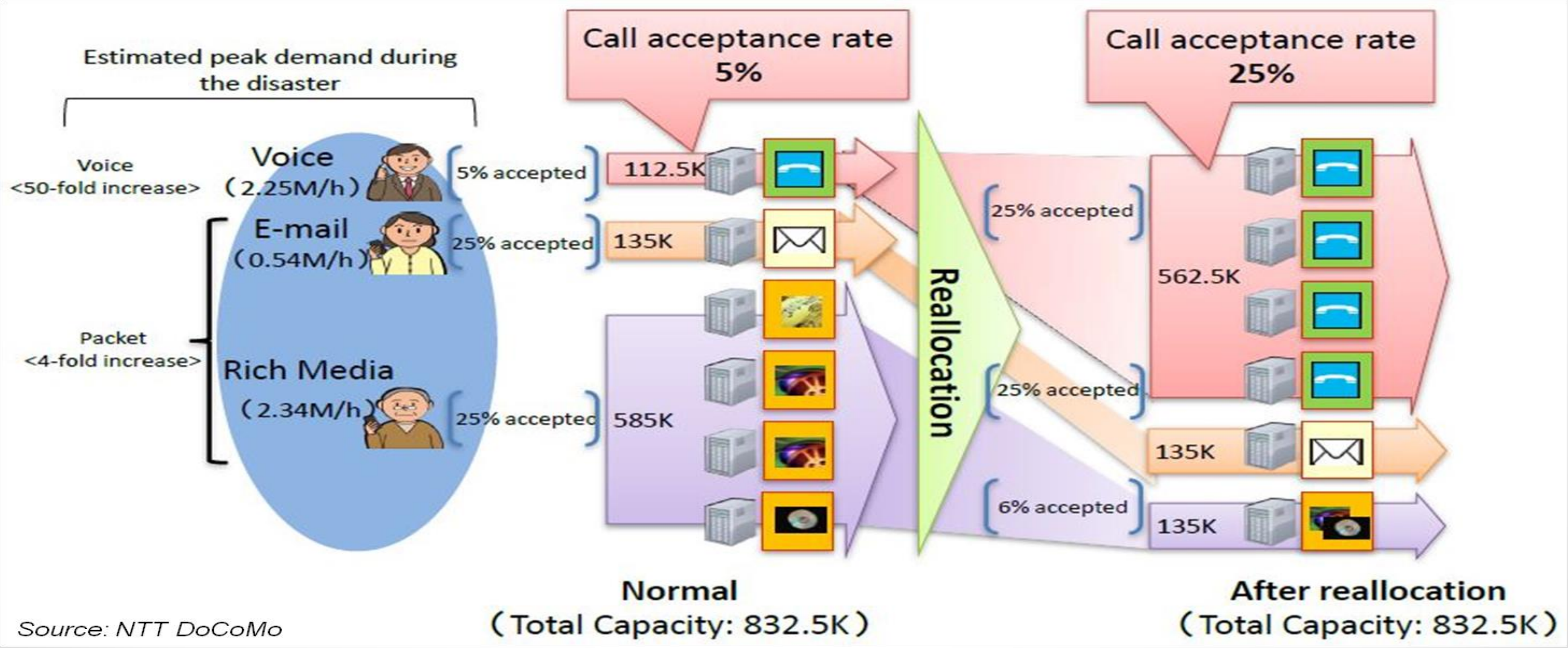


NFV with the SDN Control Plane



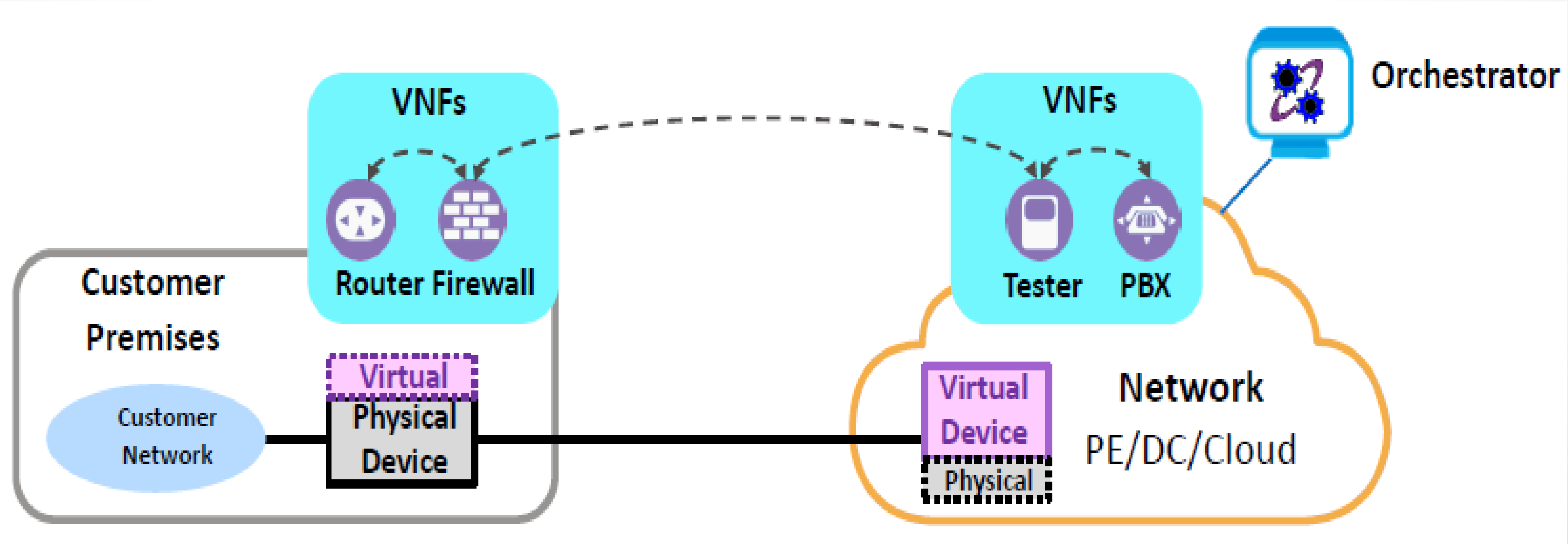
Example

- NTT DoCoMo – dynamic redistribution of resources



vCPE – Virtual Customer Premise Equipment

- The client has a small box, a weak CPU, tagging support (as a rule)
- Part of the services at the client, part in the cloud
  - NAT, FW, DHCP, ACL, QOS
  - Personal Area
- Configuration - SDN, Dynamic Service Raising - NFV



Conclusion

- The evolution of network services
  - Proprietary hardware
  - Software solutions on regular servers
  - Virtual solutions in the clouds
- Virtual machine is a unit of control
- Flexibility, scalability, performance

SiliconANGLE » NFV Will Cause A Paradigm Shift For Telcos | #HPdiscover

NFV will cause a paradigm shift for telcos | #HPdiscover

MIKE WHEATLEY | JUNE 11TH

Conclusion: SDN/NFV

- SDN – software control and management of computer networks
- NFV – launching of network services as programs in a virtual environment
- SDN+NFV – independent and complementary technologies, strength in their simultaneous application: for example, orchestration of virtual services.
- SDN/NFV World Congress video
  - https://vimeo.com/111458169