NOKIA

NFV Virtualisation & SDN

- Ing. Matej Kultan, PhD.
  - IP Optical Networks, Regional Sales Engineer

- 07-11-2016 Žilina

Virtualization towards Cloud based network

Evolution of IP routing

1993–1998

MULTI-PROTOCOL ROUTING

- Enterprise networking
- All protocols
- Cisco as innovator

1998–2003

INTERNET ROUTING

- IP for Internet services
- Hardware fast path
- BGP-centric
- MPLS acceptance
- Juniper as innovator

2003–2012

SERVICE ROUTING

- IP for all services
- Network processors
- High Availability
- Service-centric
- Alcatel-Lucent as innovator

2013–Future

CLOUD-OPTIMIZED ROUTING AND TRANSPORT

- System/network level
- (Re)thinking
- Automation
- Optimization
- Visibility & Control
- Efficiency & Scale
- Simplification

- New frontier!

NOKIA

The networks need to evolve

NFV

Flexibility
and
optimization

Network fabric

Scale
and efficiency

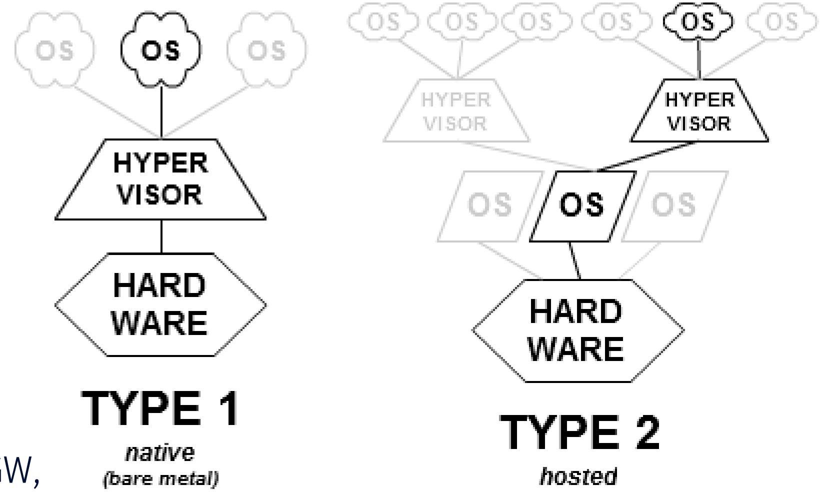
SDN

Visibility
and control

Network services will become abstracted from locations and physical devices

Quick Check
Do you know?

- Virtualization
  - Hypervisor - KVM, VMWare, VirtualBox, Hyper-V
  - Benefits: Vertical/ Horizontal Scaling
  - Orchestration
- HW
  - ASIC, FPGA, NPU, CPU (x86)
- NF(V)
  - BNG/BRAS, RGW, WLAN GW, NAT, MG, DPI, FW, DCGW,
  - PE, RR, SecGW,..
- SDN
  - SD-VPN, DC Overlay, SD-WAN, Service Chaining



Virtualisation

Recap

Virtualisation Recap
Types of Virtualisation

- Emulation
  - Make one system behave like or imitate a different one
  - Take an entire system and make it run on a platform it was not designed for (includes totally different CPU architectures) (Example: play your Sega Megadrive games on your PC)
  - Huge performance impact
  - Very useful for ensuring the continuation of required legacy hardware/software and for migrations

Virtualisation Recap
Types of Virtualisation

- Virtualisation
  - Known as many things (HVM, Accelerated Virtualisation, Hardware Assisted Virtualisation, Native Virtualisation) (Example: x86 Windows PC running VMware workstation with Linux as the guest)
  - Turns physical resources into logical resources which can be supplied/requested to/from guests
  - Host and Guest architectures must be the same architecture (e.g. x86_64)
  - Guests use unmodified drivers to connect to the virtualised resources
  - Calls to hardware need to be intercepted by the hypervisor

Virtualisation Recap
Types of Virtualisation

- Para-Virtualisation
  - The code of an operating system is modified in order to allow that operating system to run as a guest
  - Rather than calls being made by the guest to hardware which are then intercepted by the hypervisor (VMM) and converted the calls are instead made from the guest directly to the VMM.
  - Provides better performance
  - The VMM is aware of the requirements on the guest(s) and can manage resources accordingly
  - For high I/O where the guest knows that it is virtualised
    (most situations these days) para-virtualisation
    (VirtIO drivers on KVM, VMware Tools on VMware) should be used

Virtualisation Recap
Hypervisors

- Also know as a Virtual Machine Manager (VMM)
- Interfaces with the physical host hardware allowing it to be presented to multiple virtualised guests
- Marshals the sharing of resources between guests (access to CPU, GPU, Memory and other hardware)
- Two types
  - Type 1: Native/Bare-Metal Hypervisors (**VMware ESXi**, Microsoft Hyper-V, Citrix XEN)
    The host operating system is the Hypervisor software. Hypervisor has direct access to all hardware and features of the underlying machine.
  - Type 2: Hosted Hypervisors (VMware Workstation, Parallels, Oracle Virtual Box)
    Relies on the underlying host operating system for access to the hardware. If the underlying host O/S develops an issue the guests can fail. Linux **KVM** is often treated as a type-1 but is really a type-2 hosted Hypervisor.

Service Router Evolution
Virtualised Service Router

VSR targets flexible, distributed, data-centre, emerging and rapid deployment markets

NOKIA

Service Router Evolution

Over a decade of Service Routing experience

Service Router Portfolio

5620 SAM

SROS

x86		FP3 - FPGA			C-NPU	C-ASIC
VMG	VSR (NEW)	7750 SR	7450 ESS	7950 XRS	7705 SAR	7210 SAS

Virtualised
x86 Architectures

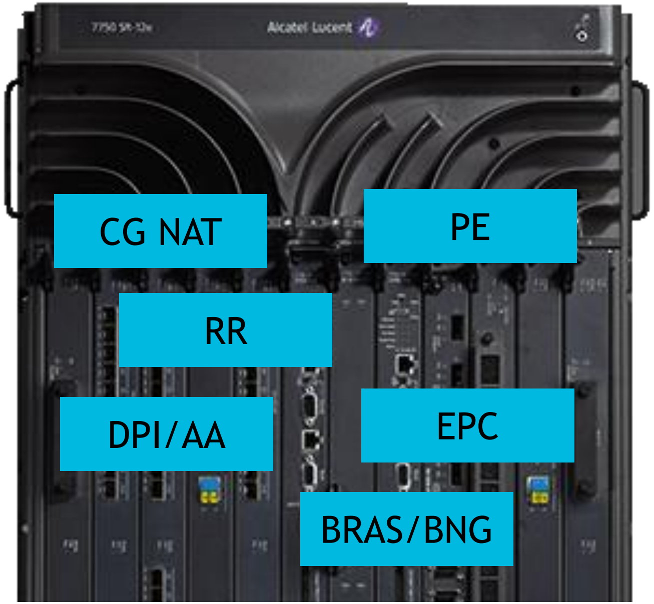
Integrated
Custom Routing NPUs

Integrated
Commercial NPUs, ASICs

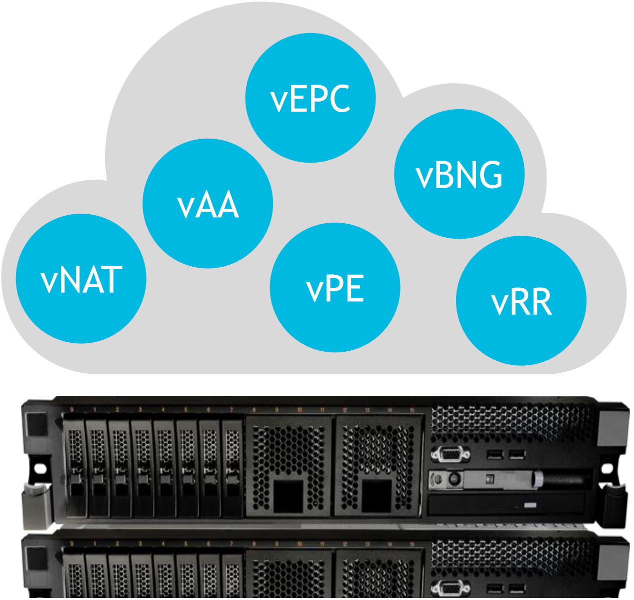
470K+ Systems Shipped, 1100+ Customers, 130+ Countries

Network Function Virtualization (NFV)

SPECIALIZED
CUSTOM ROUTING NPUs



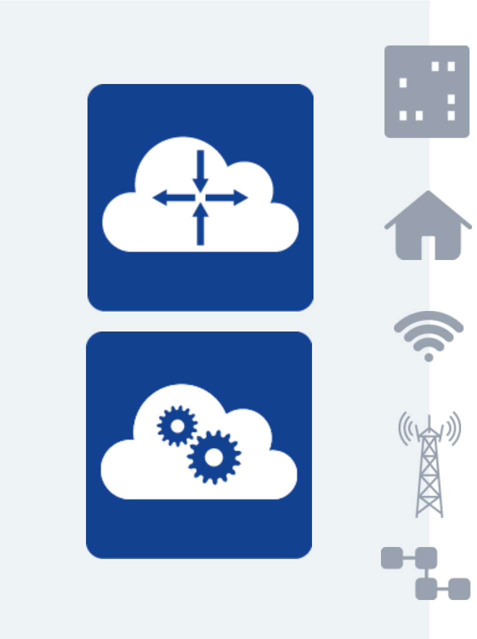
VIRTUALIZED
x86 ARCHITECTURES



Decouples networking functions from specialized hardware
Standard IT virtualization technology to offer VNFs on x86 servers

Nokia ION virtualization portfolio and solutions

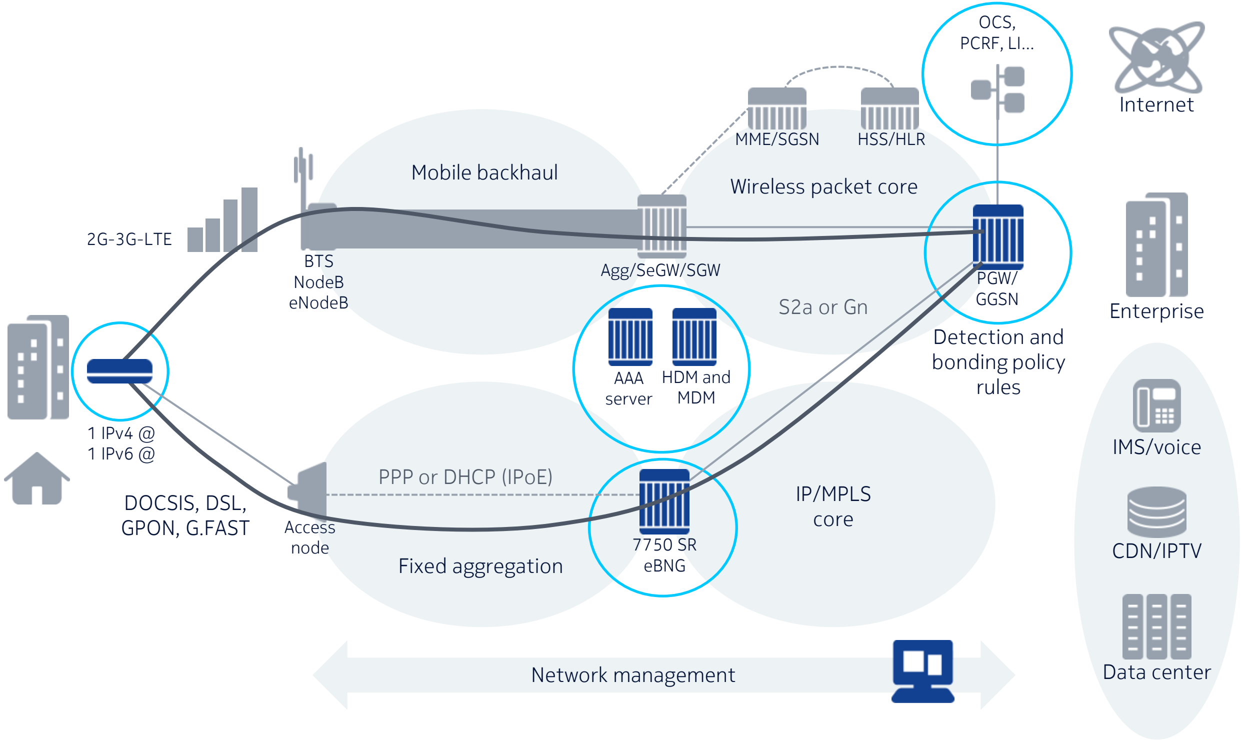
Driving the expectations of the industry



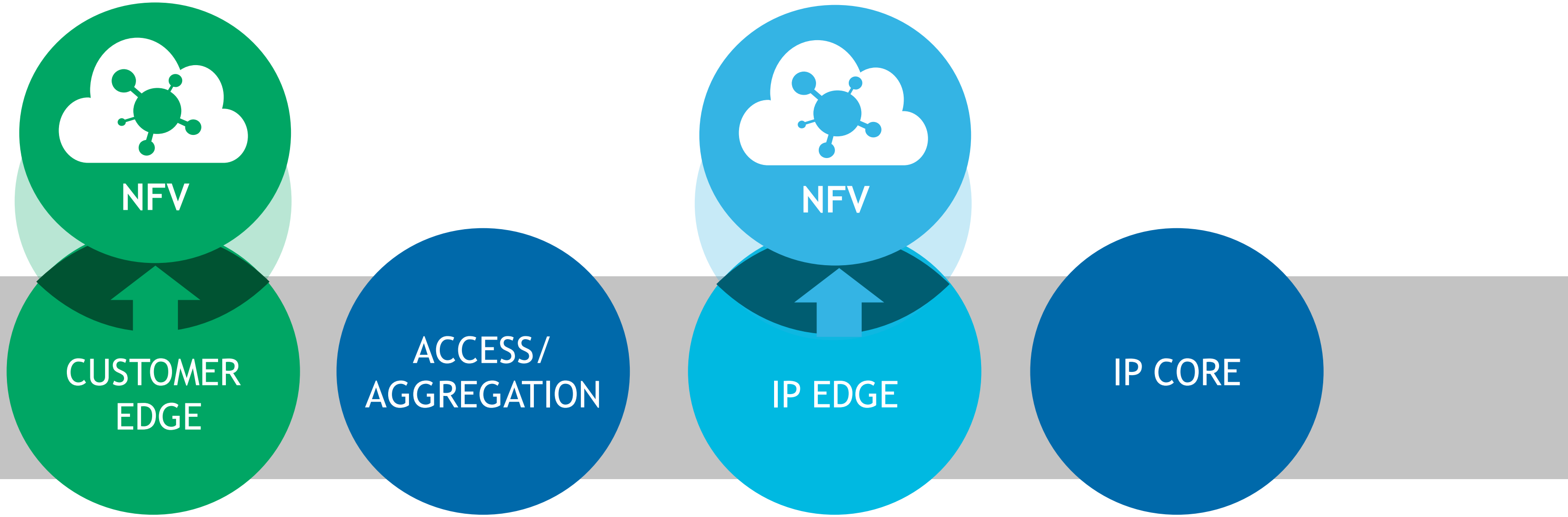
Route Reflector	Provider Edge	Trusted Wireless Access Gateway (TWAG)
Routing Simulator	Broadband Network Gateway (BNG)	Security Gateway
SGW/PGW/GGSN	Application Assurance (AA)	Network Address Translation (NAT)
Evolved Packet Data Gateway (ePDG)	Data Center Gateway	Residential Gateway

NOKIA

Evolved Packet Core example



NFV applicability in the network



NFV opportunity in the customer edge and IP edge

Alcatel·Lucent

NFV deployment drivers

NFV

AGILITY

On-demand service delivery through automation

SCALE ELASTICALLY

Scale-up, out or down as required

Exploit multi-tenancy efficiencies

OPERATIONAL EFFICIENCIES

Efficiency of homogenous hardware

Place functions where and when needed

REDUCE RISK

Easier application tuning & service customization

Lower financial risk to test new applications

Target applications for virtualization in the IP edge

NFV

COMPUTE-INTENSIVE

Route Reflector
Mobility Manager

NFV

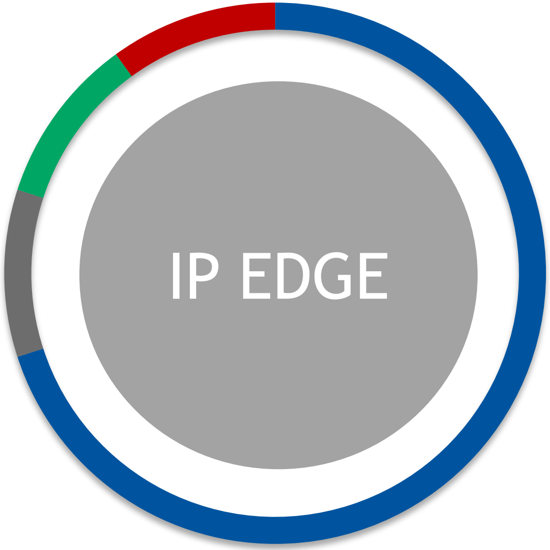
L4-7 PROCESSING

Application Assurance
Address Translation

NFV

IP SERVICES

Small Provider Edge
Small Gateways

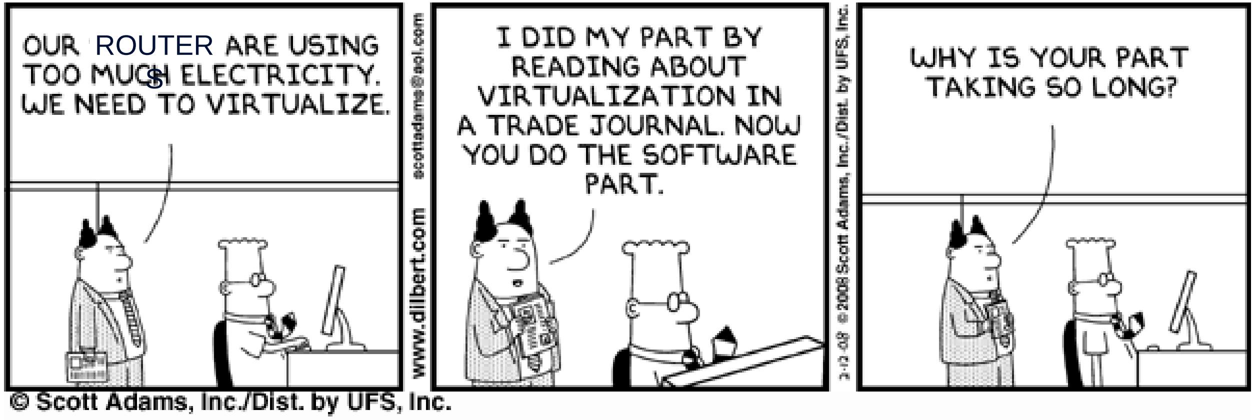


IP SERVICES

Provider Edge
Gateways

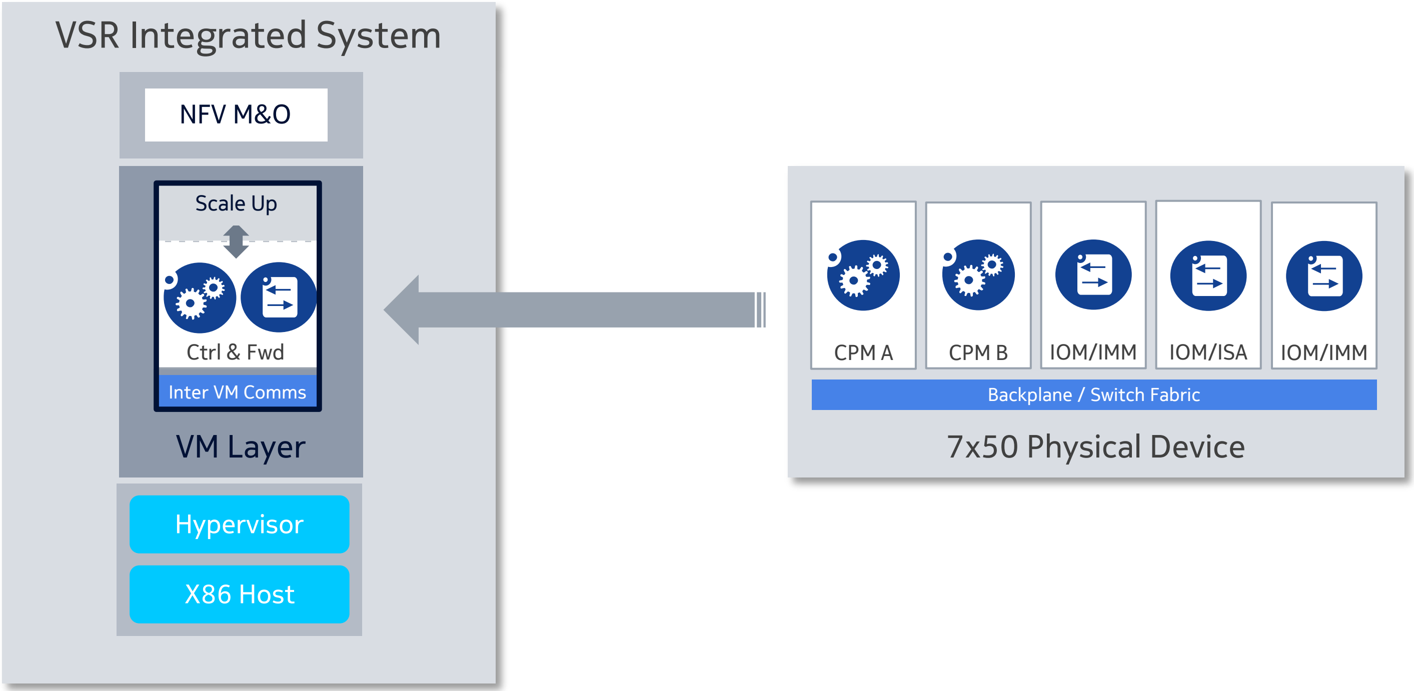
SPECIALIZED HARDWARE

VSR
Architecture



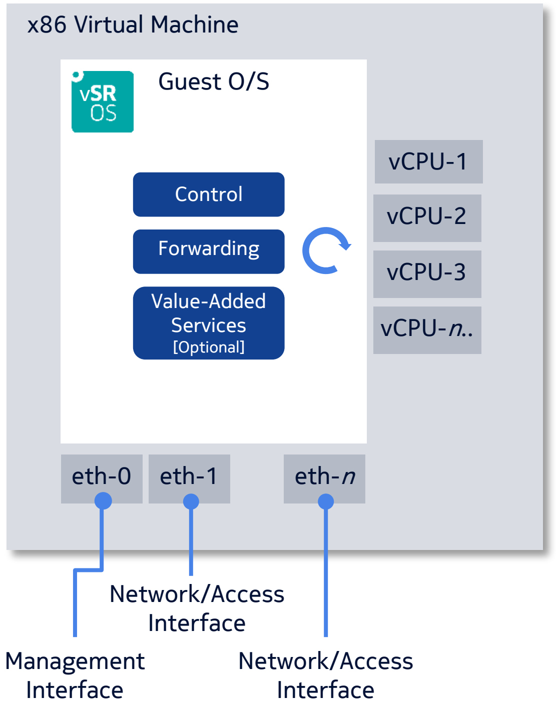
  Nokia Internal Use

Virtualised Service Router
Integrated Model



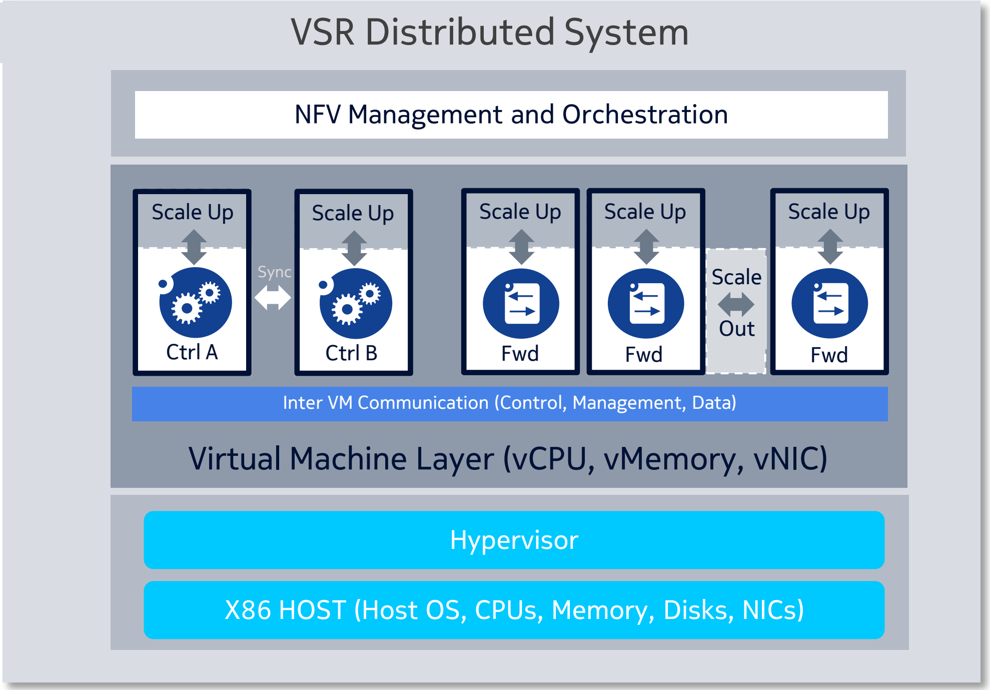
1 x VSR = 1 x Virtual Machine

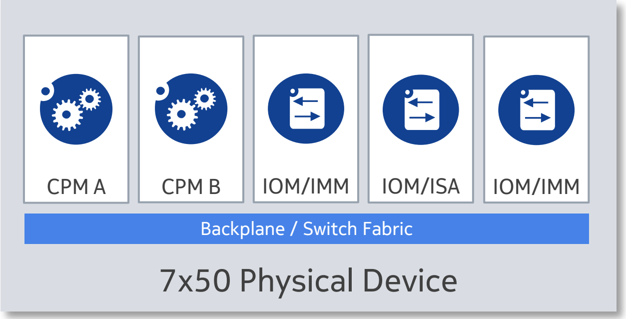
Virtualised Service Router
Integrated Model



- Virtual CPUs and memory of the VM are dynamically shared between:
  - Control tasks: BGP, OSPF, LDP, RTM, policies, etc.
  - System management tasks: Netconf, SNMP, Telnet, etc.
  - Forwarding plane tasks
  - Optional value-added services: IPSec, NAT, AA, etc.
- VSR can be scaled vertically
  - Adjust the number of vCPUs and the amount of virtual memory to proportionally scale control and data plane capacities
  - Minimum of 2 vCPUs

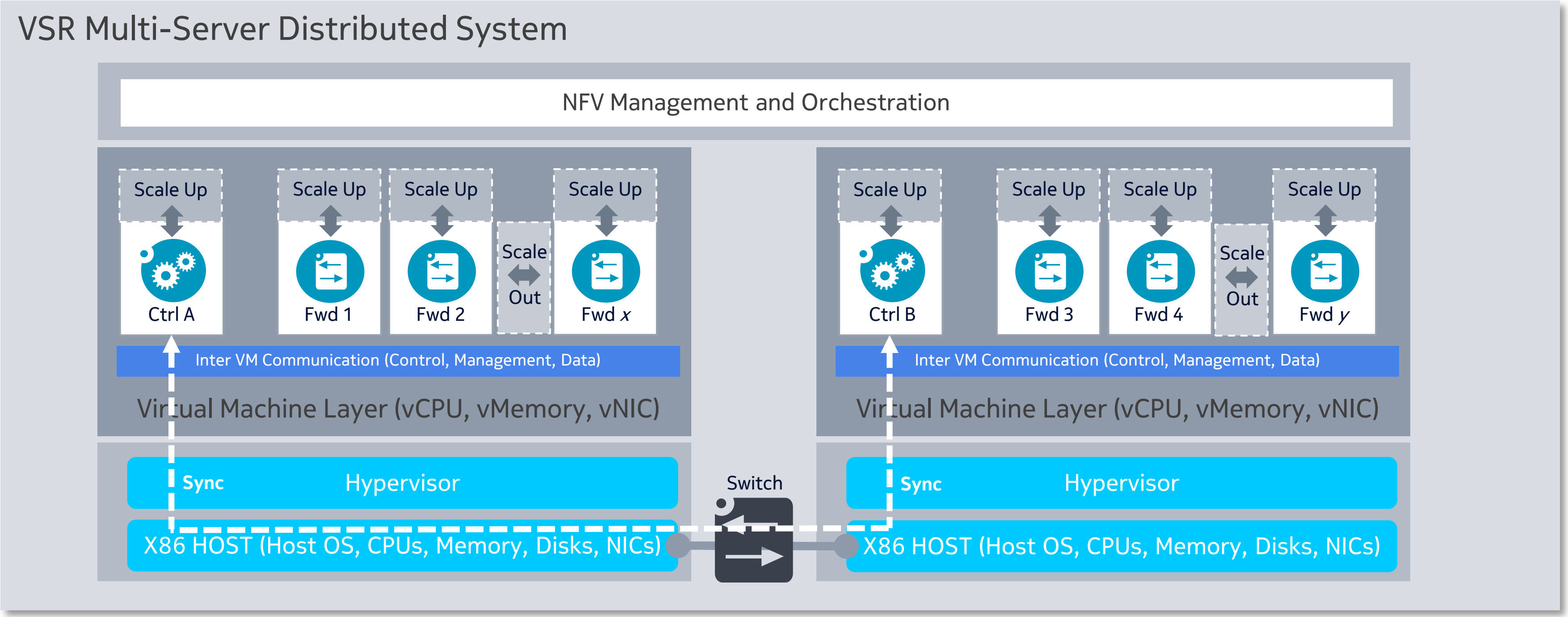
Virtualised Service Router
Distributed Model





1 x VSR = n x Virtual Machines (Where n >= 2)
Initial release will support 2 x Control-VMs and 1 x Forwarding-VM

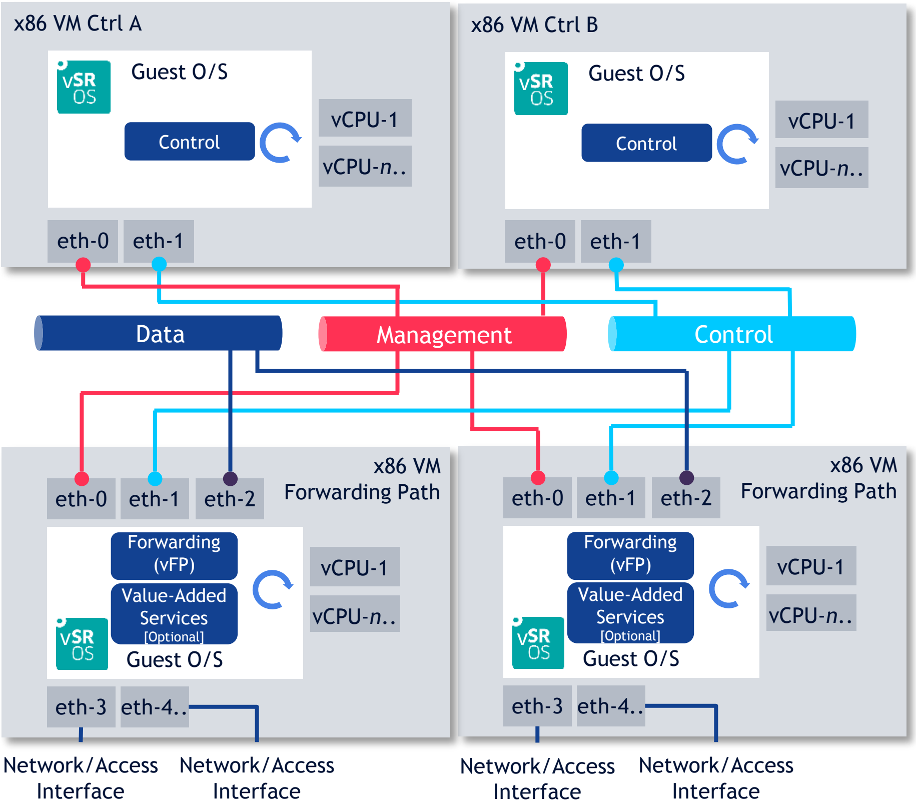
Virtualised Service Router
Multi-Server Distributed Model



Single VSR. Multiple physical servers
Initial release will support 2 x Control-VMs and 1 x Forwarding-VM

NOKIA

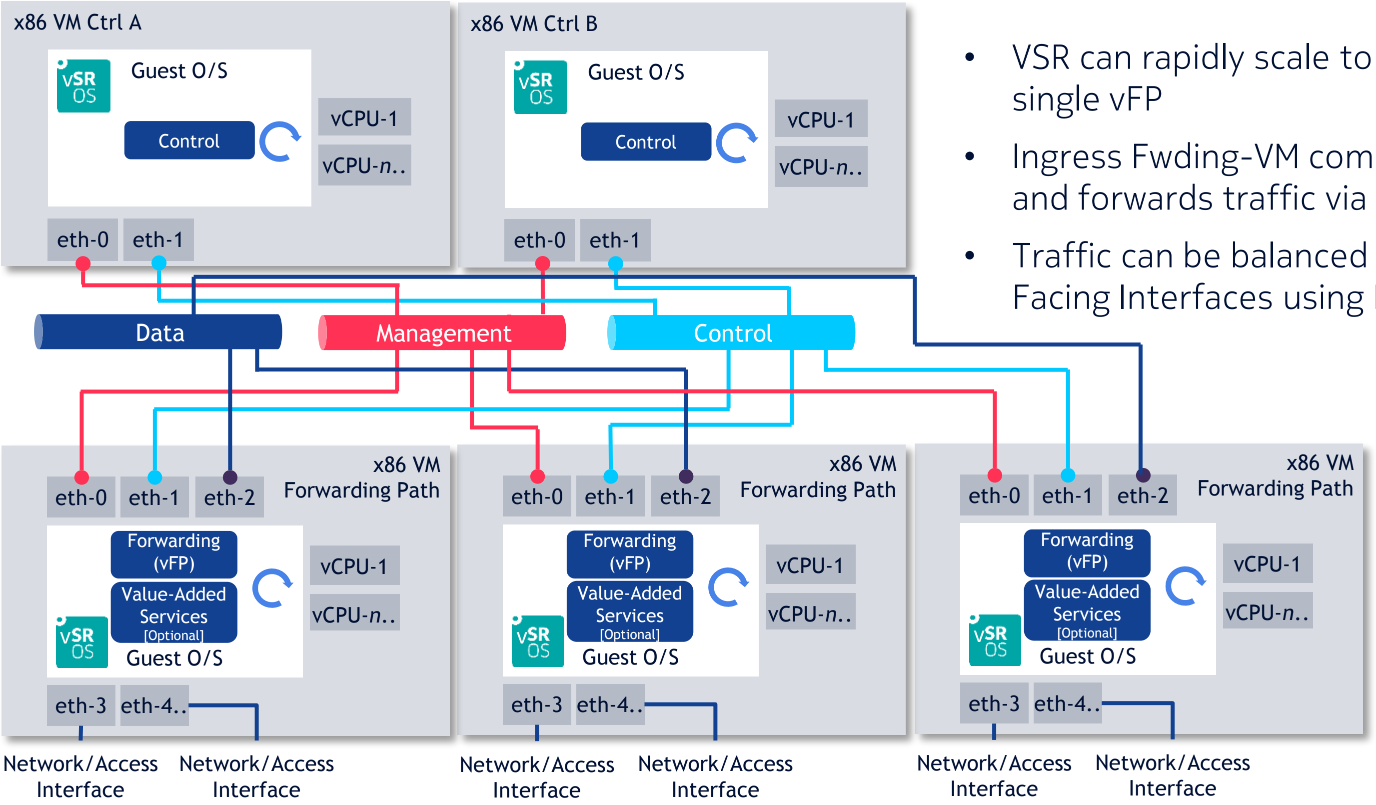
Virtualised Service Router
Distributed Model



- Control-VM (1 or 2 for redundancy) run control and system management tasks (BGP, OSPF, LDP, RTM, policies, Netconf, SNMP, telnet, etc.)
- Forwarding-VM (1-14) perform packet forwarding and value-added services (if desired)
- Ctrl-VMs and Fwding-VMs communicate via:
  - Management interconnect, used for OOB management
  - Control interconnect, used for internal control messaging; VM discovery, FIB updates, stats collection, etc.
  - Data interconnect, carries traffic from ingress Forwarding-VM to egress Forwarding-VM
  - VSR is designed to be as agnostic as possible to the underlying Ethernet fabric used to interconnect VMs

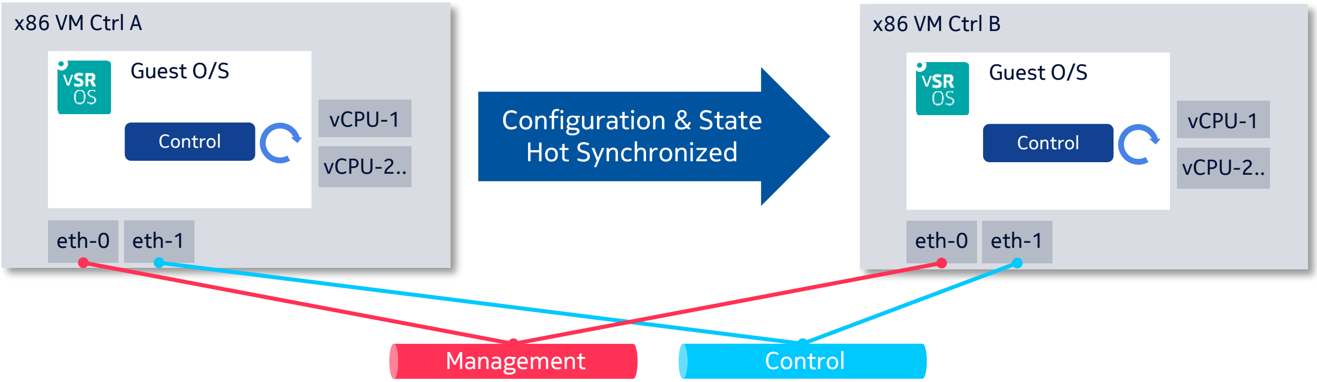
NOKIA

Virtualised Service Router
Distributed Model



- VSR can rapidly scale to N times the capacity of a single vFP
- Ingress Fwding-VM completes a forwarding lookup and forwards traffic via the intra-device data-plane
- Traffic can be balanced between VMs on Access-Facing Interfaces using ECMP or LAGs

Virtualised Service Router
High Availability (HA)



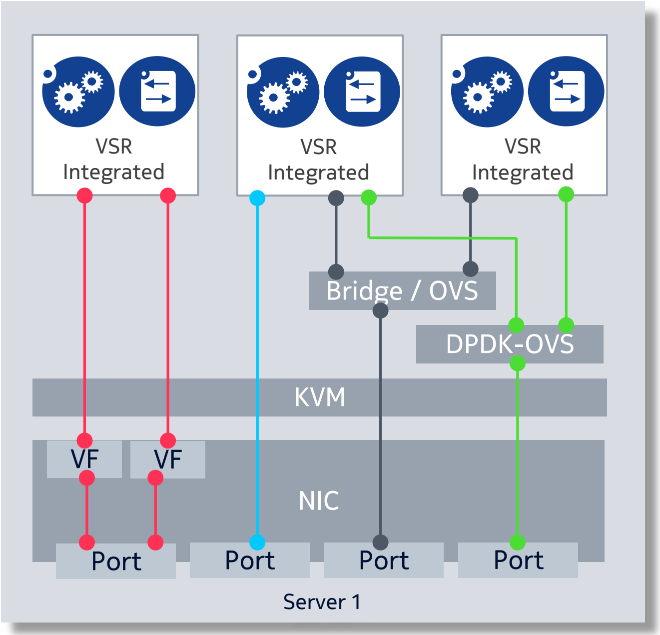
- Configuration and state information is hot synchronized between Control-VMs to provide state-full failover
  - Services state
  - Protocol state (BGP RIB, OSPF LSDB, etc.)
  - TCP connection state

- In case of failure, the standby Control-VM takes over immediately without any impact on forwarding, services, protocol adjacencies, etc.
- Control plane HA also allows for in-service software upgrade (ISSU)

NOKIA

Virtualised Service Router
Virtualised I/O Support

- Linux Bridging
  - Intra-server only
- Openvswitch (OVS)
  - Flexible, programmable
- DPDK (Data Plane Development Kit) Accelerated OVS
  - Flexible, programmable & increased performance over bridging/OVS
- SR-IOV {Single-root input/output virtualization)
  - Virtual Functions created in hardware to share ports
  - Highest throughput with cloud flexibility
- PCI-Passthrough
  - Highest throughput with no flexibility

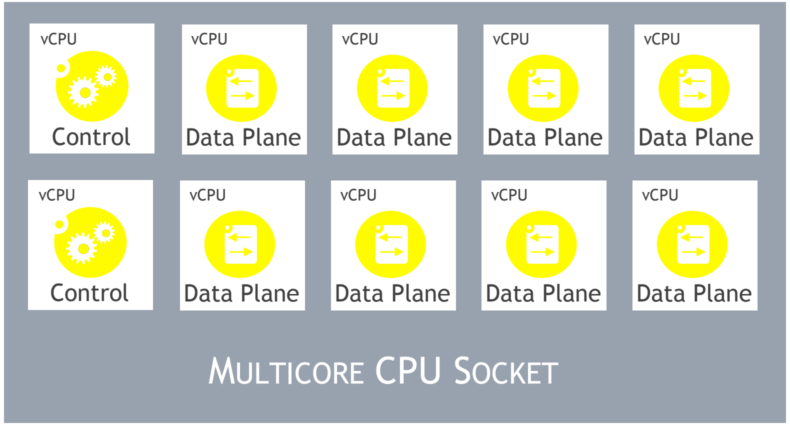


VSR

Performance and Scale

NOKIA

VSR: architected for performance and scale



Symmetric Multi-Processing (SMP)

- Active tasks are distributed across multiple cores
- Automatic SMP in any VSR VM for data plane and control plane tasks
- Supported in SR OS since 2007

64-bit Operation

- Support for 64-bit virtual machines
- Single task can access >4GB of memory
- E.g.: BGP RIB can scale to ~100M routes in a control plane VM with 16GB of memory

Symmetric Multi-Processing(SMP) and 64-bit OS are Essential Technologies for NFV

Virtualised Service Router
Performance and Scale

- **Scale**

Typical PE Metrics

IP routes	IGP LSAs/LSPs
ARP entries	LSPs/tunnels
IP interfaces	Filter rules
BGP peers	Policers
IGP adjacencies	MAC FDB entries

KEY VSR TECHNOLOGY

64-BIT OS

- **Performance**

Typical PE Metrics

- Packet forwarding rate (PPS)
- Route adv/withdrawal rate
- Route programming rate
- Service creation rate
- Tunnel setup rate

KEY VSR TECHNOLOGY

SMP

Virtualised Service Router
Performance and Scale

- **Host Related**

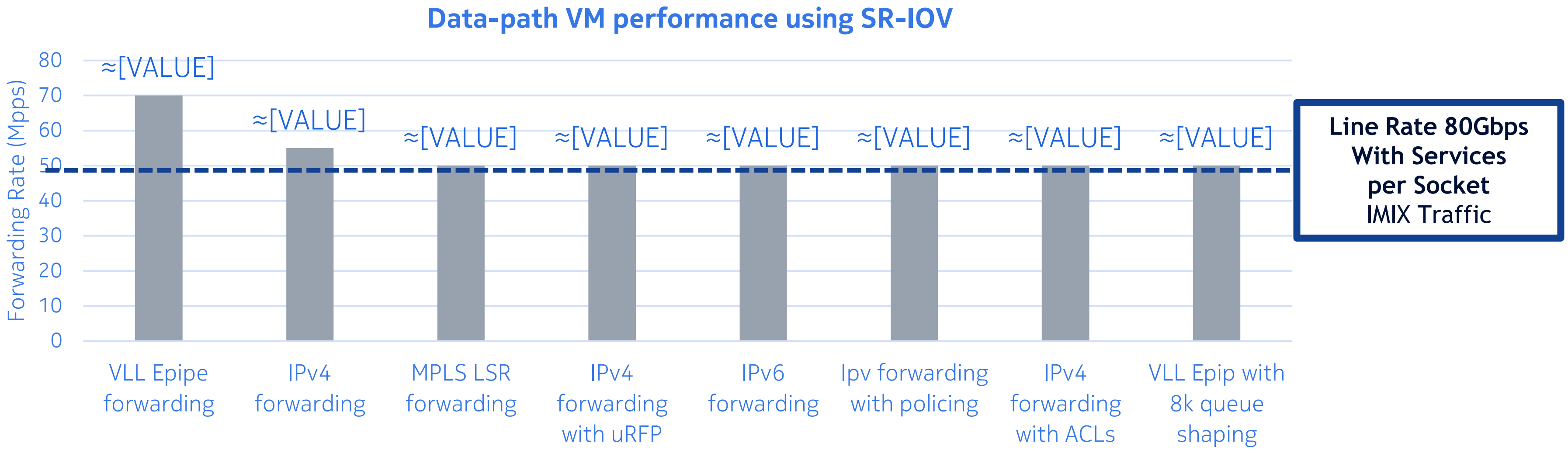
Key Factors
CPU Architecture
CPU Clock Speed (GHz)
CPU L3 Cache Size
BIOS Hyper-Threading Setting
PCI Express Bandwidth Limit
I/O Virtualisation Technology
Number of vCPUs

- **Guest Related**

Key Factors
Forwarding Path Complexity
FIB Size
Number of Interfaces
Number of ACLs
Number of Queues
Number of Services
Amount of State Held

Virtualised Service Router
Data-path Performance Test Results

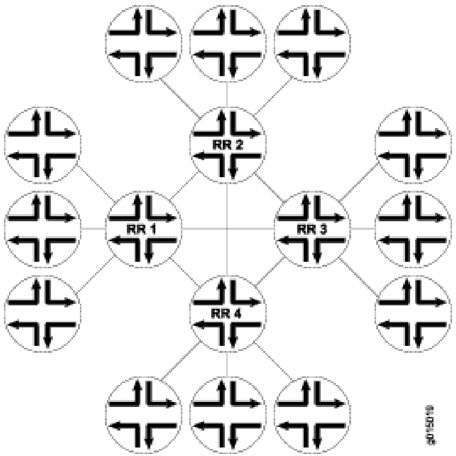
New figures coming shortly



"We have already seen an outstanding performance in the testing of Nokia's VSR, showing that it delivers comparable performance to hardware-based routers"
-Enrique Blanco Global CTO, Telefónica

VSR
Applications

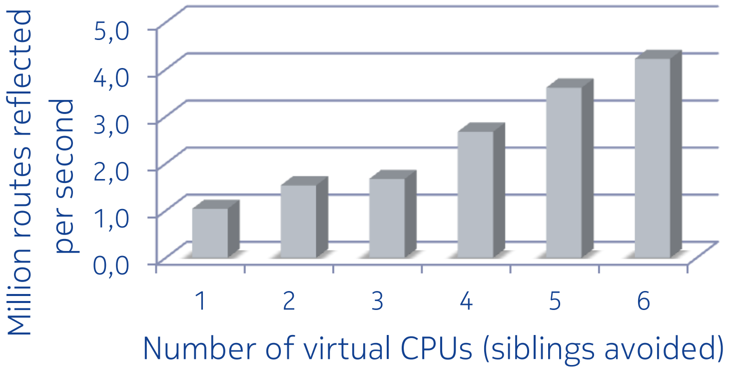
vRR SCALE AND PERFORMANCE



Scale	12.0R2 (32-bit) – 4GB VM	12.0.R4 (64-bit) – 12.8GB VM
BGP sessions	1000	1000+
IPv4 Internet paths	17M	TBD
Unique IPv4 routes (no route install)	8M	31M
Unique IPv6 routes (no route install)	7M	29M
Unique VPN-IP routes	6M	25M

vCPU Configuration	RR convergence time (300M reflected routes)
1 vCPU – Intel Xeon E5-2620 @ 2.0GHz	288s
2 vCPU – Intel Xeon E5-2620 @ 2.0GHz	195s
3 vCPU – Intel Xeon E5-2620 @ 2.0GHz	179s
4 vCPU – Intel Xeon E5-2620 @ 2.0GHz	112s
5 vCPU – Intel Xeon E5-2620 @ 2.0GHz	83s
6 vCPU – Intel Xeon E5-2620 @ 2.0GHz	71s
8 vCPU – Intel Xeon E3-1230v2 @3.3GHz	48s

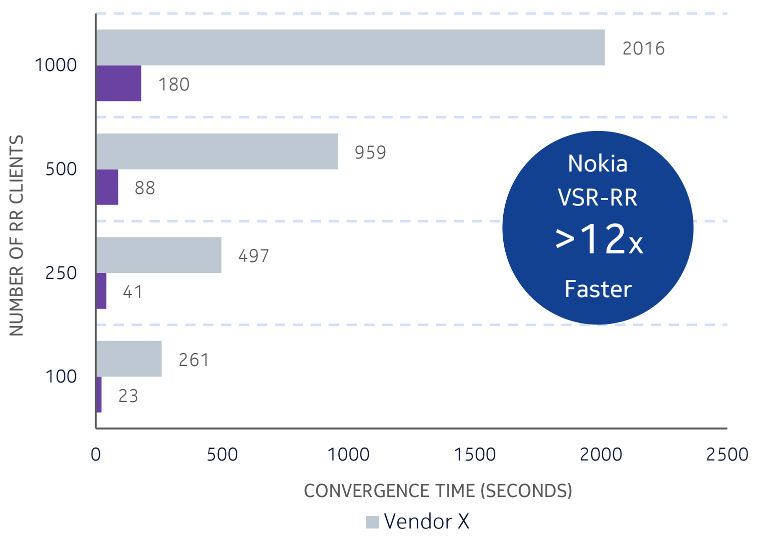
RR Convergence Performance

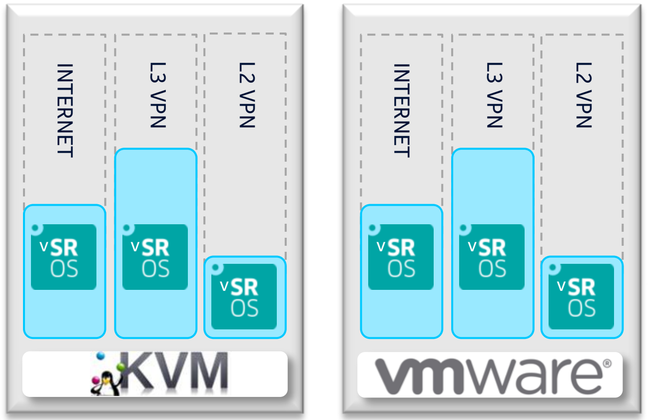


Alcatel·Lucent

VSR-RR: Route-Reflector
Flexible, High Scale, High Performance

- No need to over-provision
- Scale-up/Scale-down per VM (Router/Address-Family)





- vRR scale can be adjusted up/down as needed
- Less unused capacity
- Faster deployment of new RRs

- Reflects 51M prefixes in 23 seconds (Real Life GRT * 100 iBGP Peers)
- 5x – 10x faster than hardware solutions
- >12x faster than competitors VRR

  Nokia Internal Use NOKIA

VSR-SIM: Virtual Simulator

Maximise Flexibility and Reduce CapEx

- Physical Lab builds costly and inflexible
- Majority of Lab use is for feature or service testing
- Same Control-plane Features/Functions as physical Service Routers
- Model Hardware as well as Software
  - Multiple hardware configurations
  - A variety of logical configurations
  - A single image

KVM vmware®

Flexible solution to evolving operations, product development and laboratory requirements

  Nokia Internal Use NOKIA

VSR-SIM: VIRTUAL SIMULATOR
NETWORK FUNCTION OPTIMISATION

94%
CapEx saving

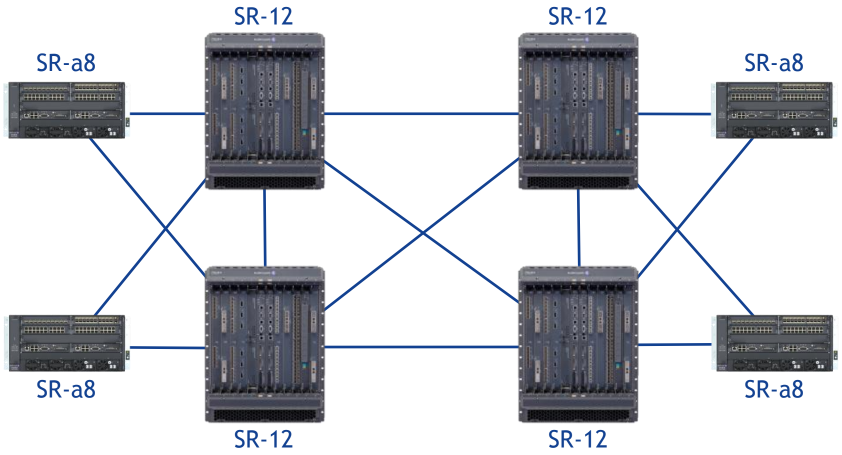
- Approximate saving using GLP
- Physical deployment shown vs. Modelling the same configuration using two VSR-SIM physical servers

83%
Power Saving

- Approximate saving when deploying two servers vs. the Physical equipment shown

97%
Smaller

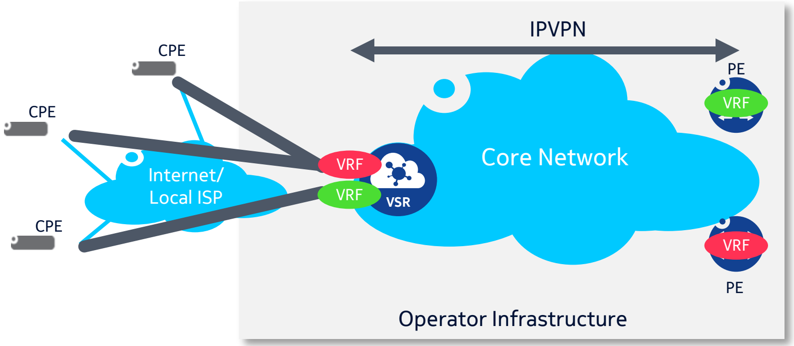
- 2RU Virtual (3.5”)
- 81RU Physical (2 full racks)

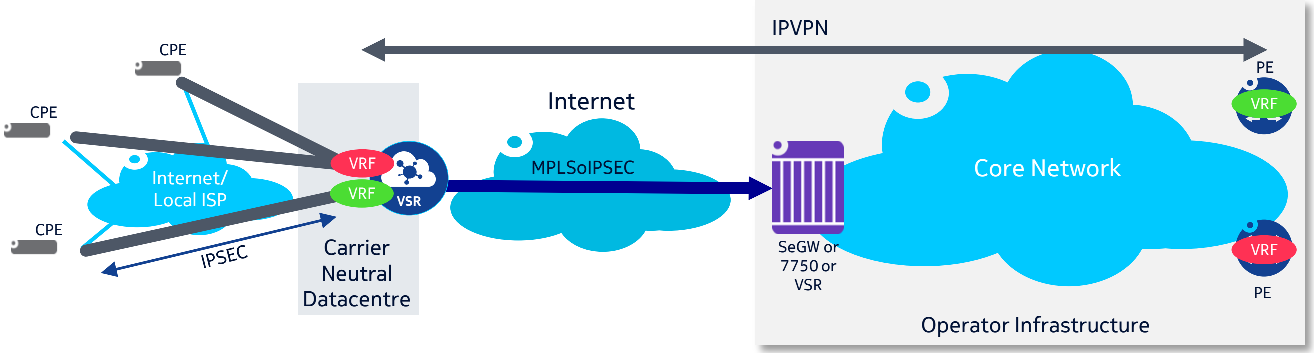


VSR-PE: Provider Edge-Router

Agile, Flexible Services where you need them most

- Typical use-cases
  - Emerging Markets
  - Legacy Device Replacements (tackle EOL issues)
  - Off-Net Business Edge
    - Internet Services with Local Internet Breakout
    - Business VPRNs
    - Layer-2 VPNs

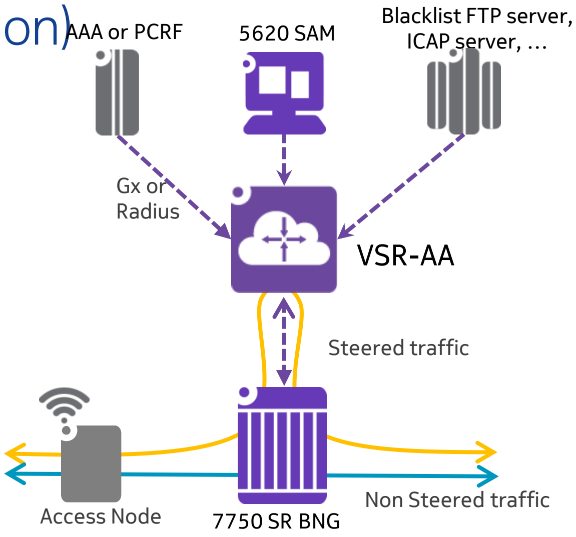


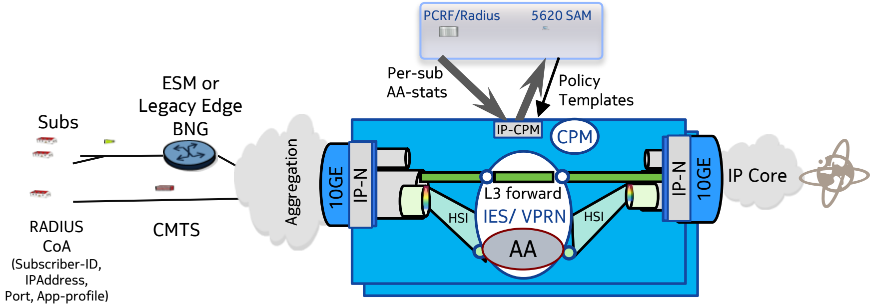


VSR-AA: Application Assurance (Deep Packet Inspection)

Augmenting the physical

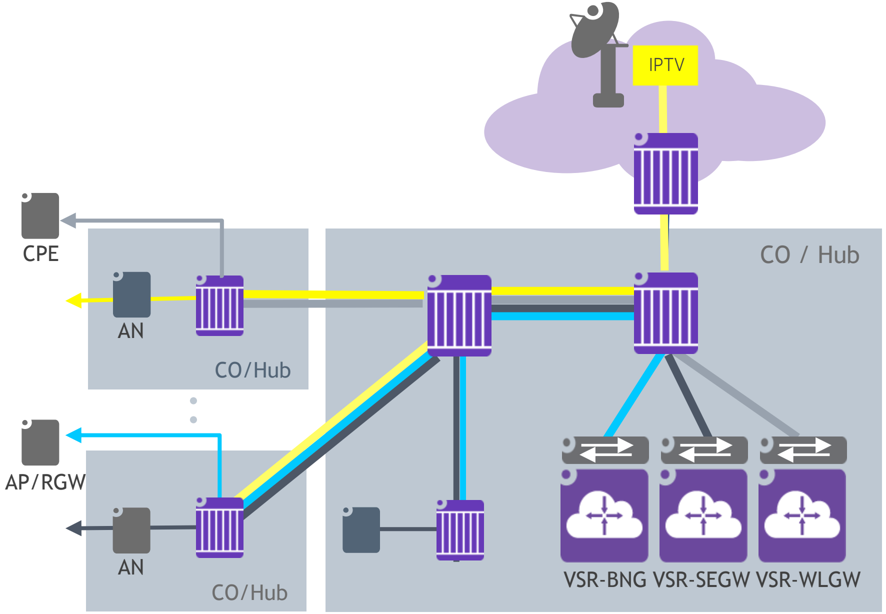
- Application Assurance is a CPU intensive operation
  - x86 processors are specifically manufactured for this type of operation
- Off-Ramp AA
  - Desire to use the physical hardware for high performance forwarding without burning slots for ISA cards
  - No ability to insert ISA cards (such as on the SR-a platform)
- In-Line AA
  - Transit traffic between the network and the BNG
  - Transparent Application Assurance





NOKIA

VSR-SEGW, VSR-BNG, VSR-WLGW

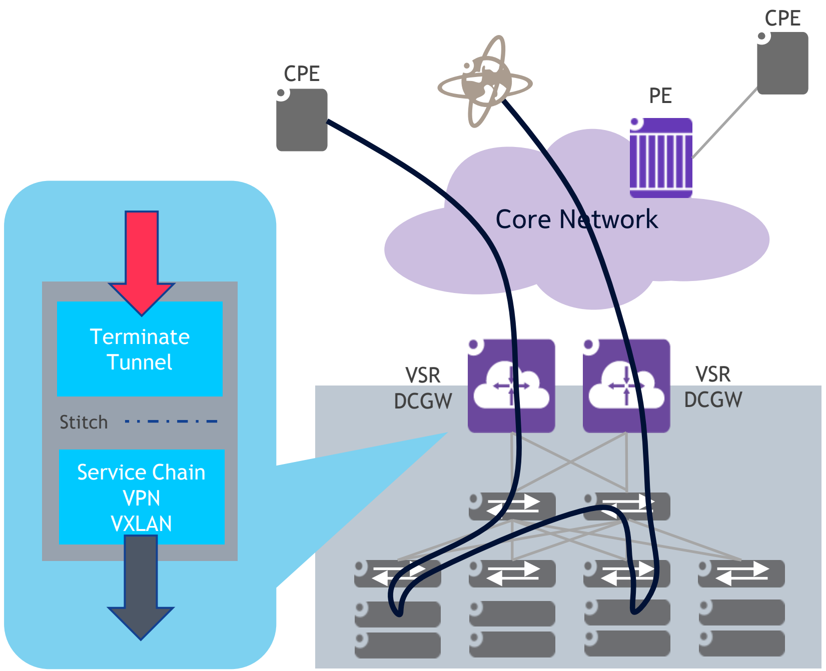


- VSR + 7750 SR deployment
  - Provider Edge
  - Broadband Network Gateway
  - WLAN Gateway
- Key benefits
  - Fully distributed deployment model for CO/hub locations and off-net locations
  - Feature and operational consistency with 7750 SR, including 5620 SAM
  - New scale models: scale-up & scale-out

Combined physical and virtual edge routing for lower cost of entry and rapid deployment

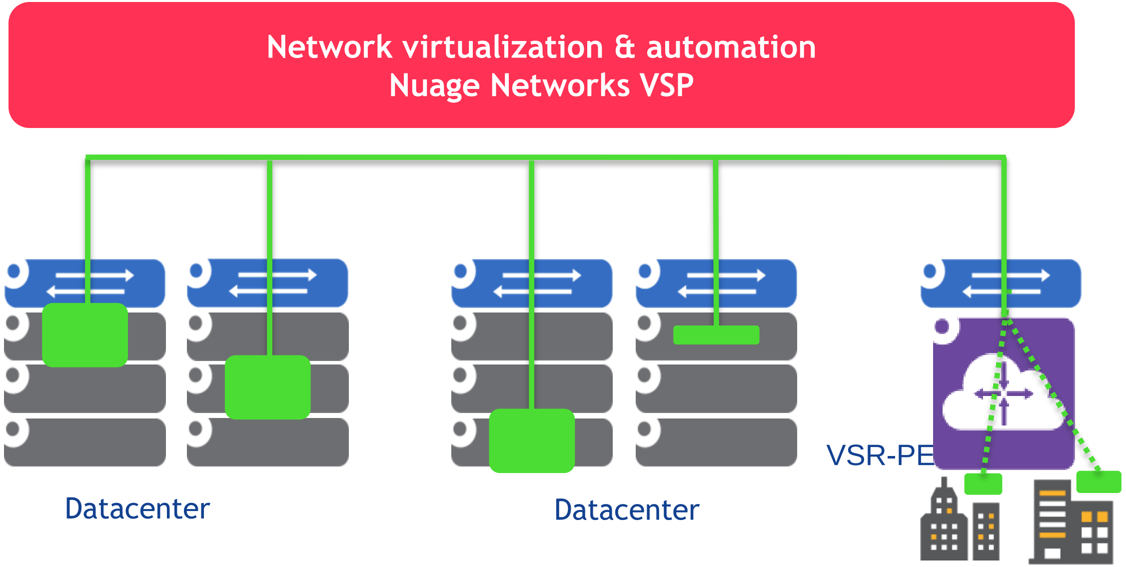
VSR-DCGW: Data-Centre Gateway

Use Data-Centre methodologies for WAN routing



- Agile creation of Data-Centre Gateways using Industry standard orchestrators
- Separation of gateways per service / customer if required
- Operational and Feature consistency with the physical SR platform
- Terminate tunnels into the Data-Centre or switch them into Service-Chain

VSR-PE: Datacenter gateway use case



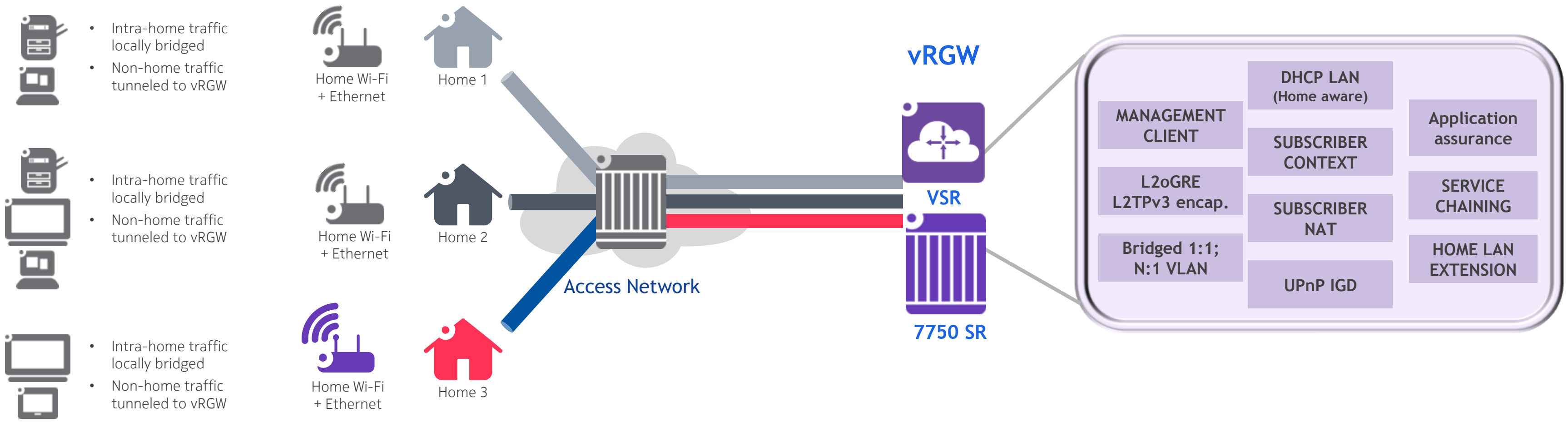
- No network configuration, No delays, No boundaries
  - Automated & seamless across DC, between DCs, to enterprise VPNs
- No new hardware
  - Open programmable approach works in any existing DC

Gateway to WAN from datacenter

VSR-RGW: Residential Gateway

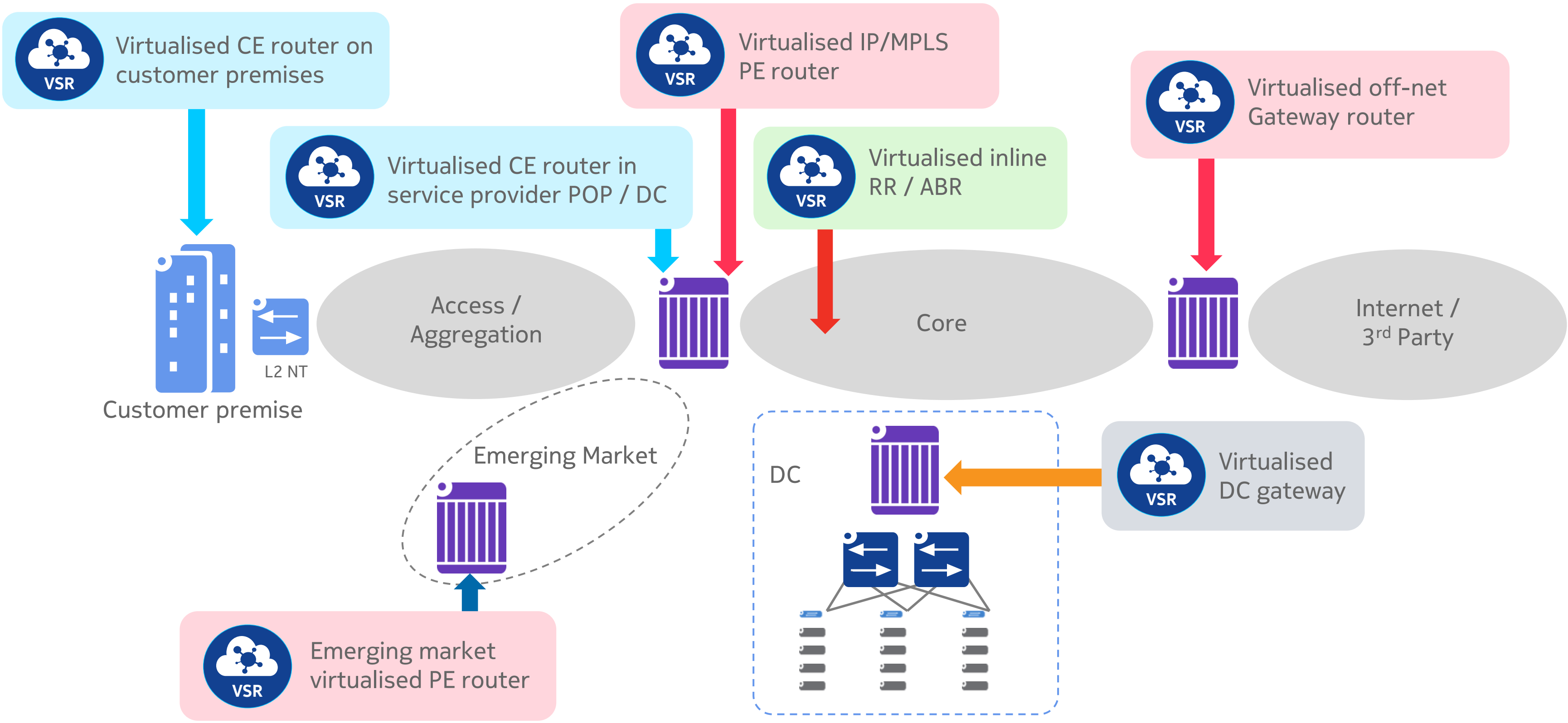
End user controlled homes and families

- Additional visibility into the home
  - Per MAC/Per user policies, features and value-add services
- Home LAN extension
  - Join multiple homes together on a single network segment



Virtualised Service Router

Potential Use Cases

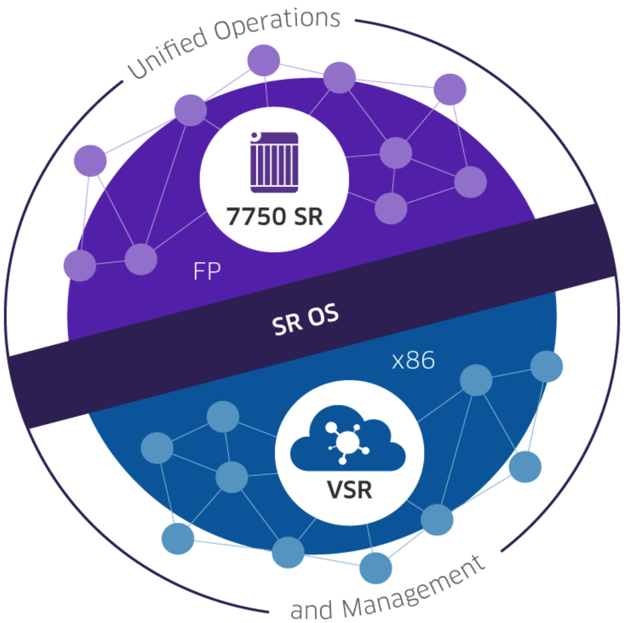


NOKIA

VSR
Summary

Virtualised Service Router

Summary



- Virtualised Service Router (VSR) is leading the way in NFV
- Same field-proven SROS operating system as 7x50 Service Routers, providing **consistent operations** across physical and virtualized network elements
- Integrated and distributed deployment models to balance simplicity vs. flexibility
- Best in class performance -> 80G (FD) throughput per CPU socket, **with services enabled** using SMP and 64-bit processing

Cloud-friendly: No strict HW dependencies, deployable in Data Centres with infrastructure managed by OpenStack, libvirt, VMWare, etc.

NOKIA

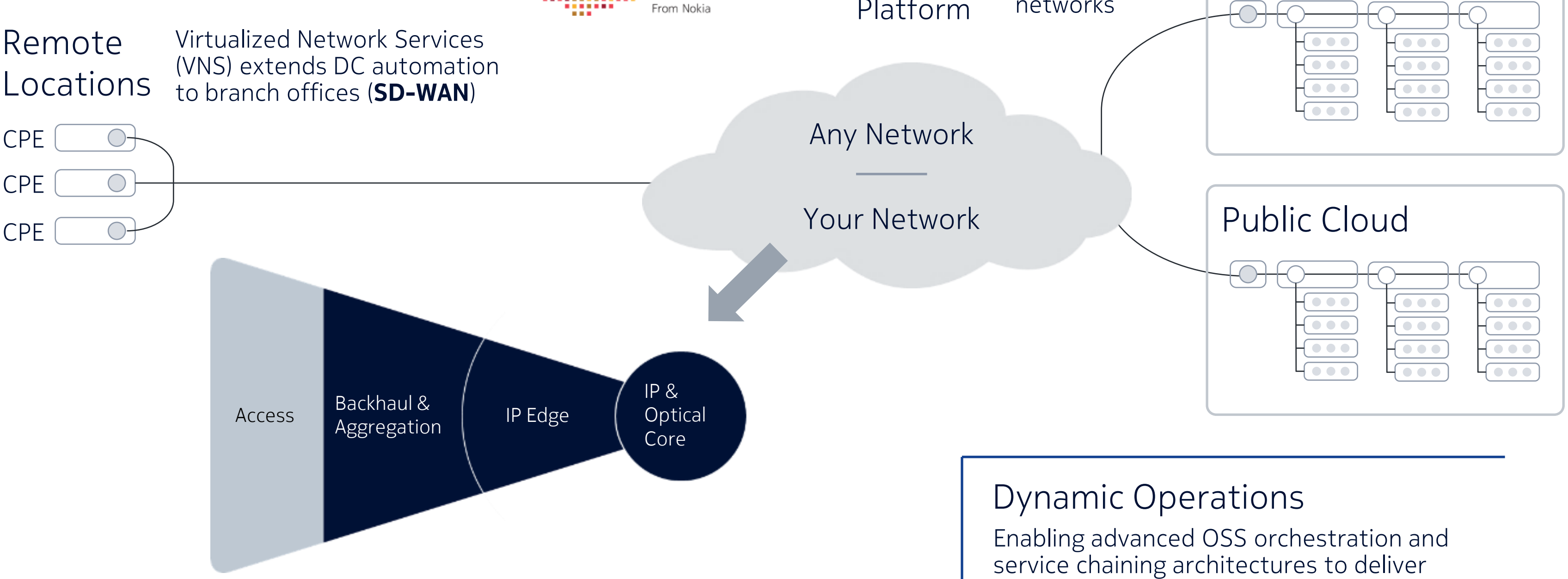
Nokia end-to-end SDN solution

Overlay and carrier SDN

nuagenetworks
From Nokia

Virtualized Services Platform automates datacenter networks

Remote Locations Virtualized Network Services (VNS) extends DC automation to branch offices (**SD-WAN**)



Network Services Platform End-to-end service automation and network optimization of multi-layer networks (**WAN-SDN**)

Dynamic Operations

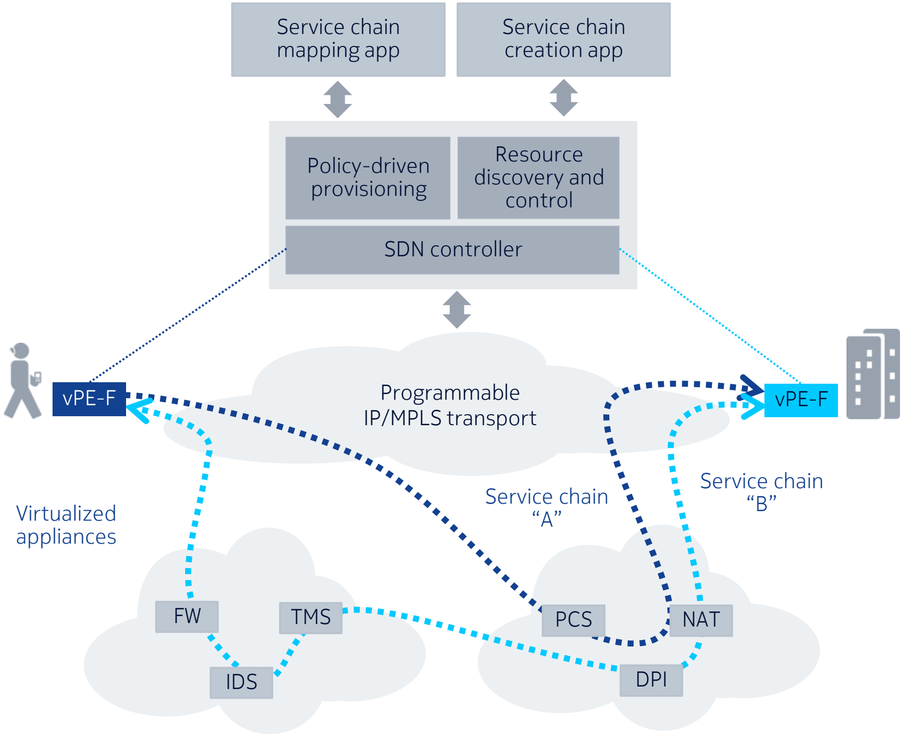
Enabling advanced OSS orchestration and service chaining architectures to deliver dynamic, on-demand network services

- fully automated from within/amongst datacenters, spanning the wide area network, and to branch office or remote locations

Opportunity: SDN for chaining (virtual) services

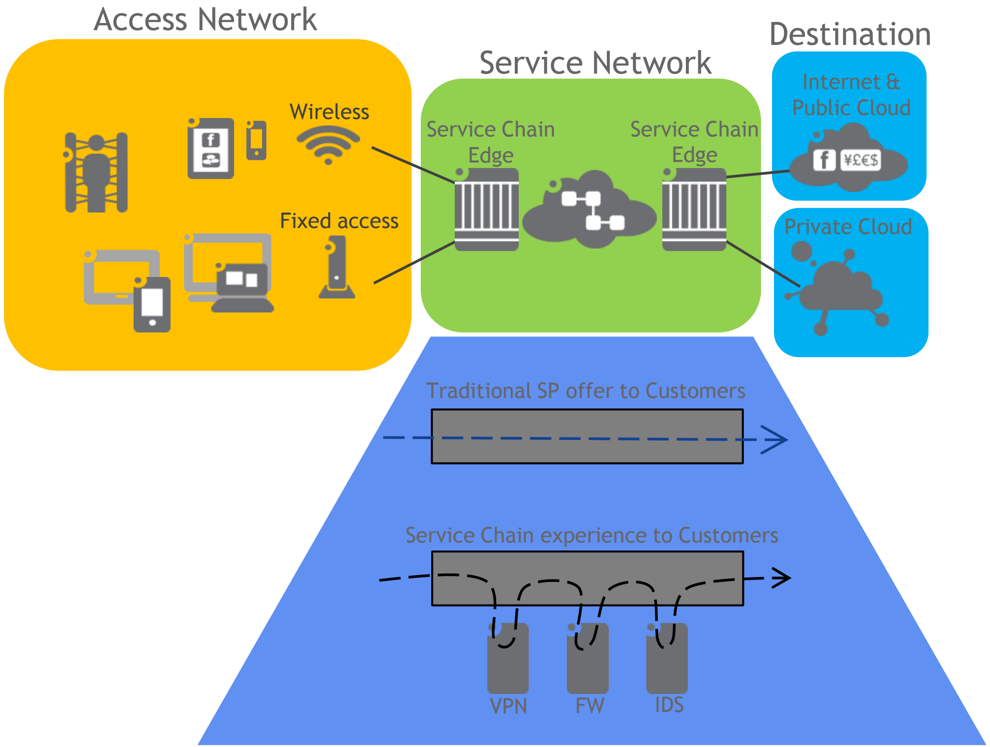
Service chaining to seamlessly connecting functions/services

- Simplify access to virtualized appliances via intelligent steering
- Quick upsell of security and other services
- Self-serve model
- Market segments
  - Enterprise
  - Residential
  - Mobile (Gi-LAN)



FW = Firewall
IDS = Intrusion Detection Service
TMS = Threat Mitigation Service
PCS = Parental Control Service
DPI = Deep Packet Inspection
NAT = Network Address Translation

Service Chaining Overview



On-demand Value Add Services per User

Service Chain Market Evolution

Static Service Chains	Dynamic Service Chains
Manual and Complex	**Automated & Simple**
Physical Appliances	Virtual, Physical or Hybrid
Manual Provisioning	Automated Provisioning
Hop-by-hop Services	Intelligent Policy L2-L7 Policy Classification
Basic L2-L3 Policy Classification	

NOKIA

Practical Service Chain use-cases

Use-Case/Domain	Mobile	Residential	Wifi	Business
Parental Control/Web-filter	V	V	V	V
Legislative/ethical blacklisting	V	V	V	V
FW	V	V	V	V
IDS/IPS				V
Anti-virus/Content inspection	V	V	V	V
Anti-spam filter	V	V	V	V
CDN/Caching	V	V	V	
WAN optimization				V
TCP Optimization	V	V	V	
Video Optimization	V			
In-Browser Notification	V	V	V	
Header Enrichment	V	V	V	
DPI (vAA)	V	V	V	V
NAT	V	V	V	V

Service Chain User Profile Analysis

	Residential	Mobile	B2B
Number of Users	+100k	+1M	+1k
Topology	Hub/Spoke	Hub/Spoke	Full Mesh
Margin potential	Low	Medium	High
SLA Requirements	Low	Low	High
Bandwidth	Medium	Low	High
Policy Control	Radius (Diameter)	Diameter (Radius)	OSS driven
Elasticity	Medium	Low	High
High Availability	Medium	Low	High

NOKIA

NOKIA

Copyright and confidentiality