lacnic 26 lacnog'16

26/30 setiembre - san josé, costa rica

whitestack

Tutorial

Introducción a SDN & NFV

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Mapa de Población

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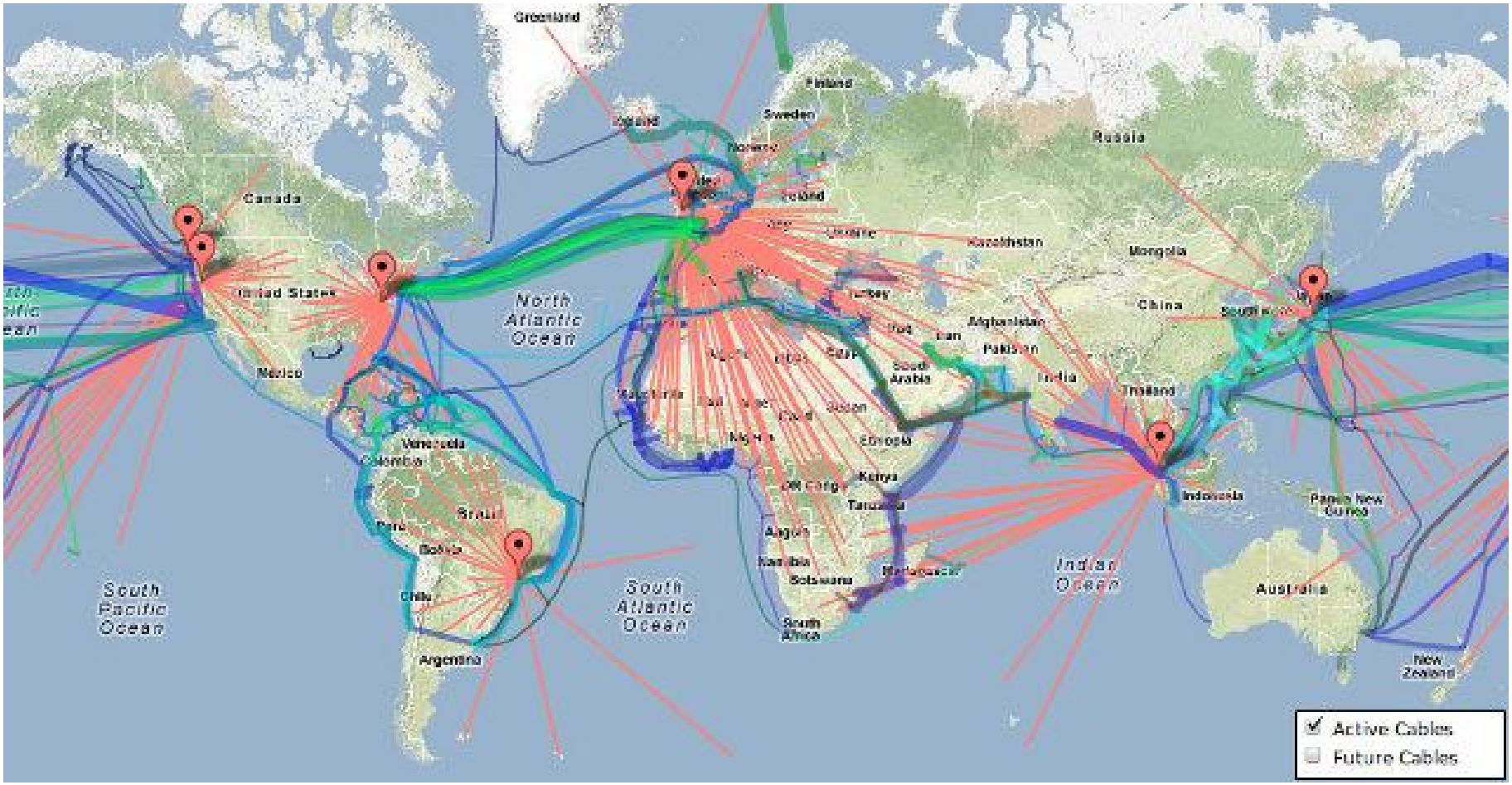
Mapa de Cables Submarinos



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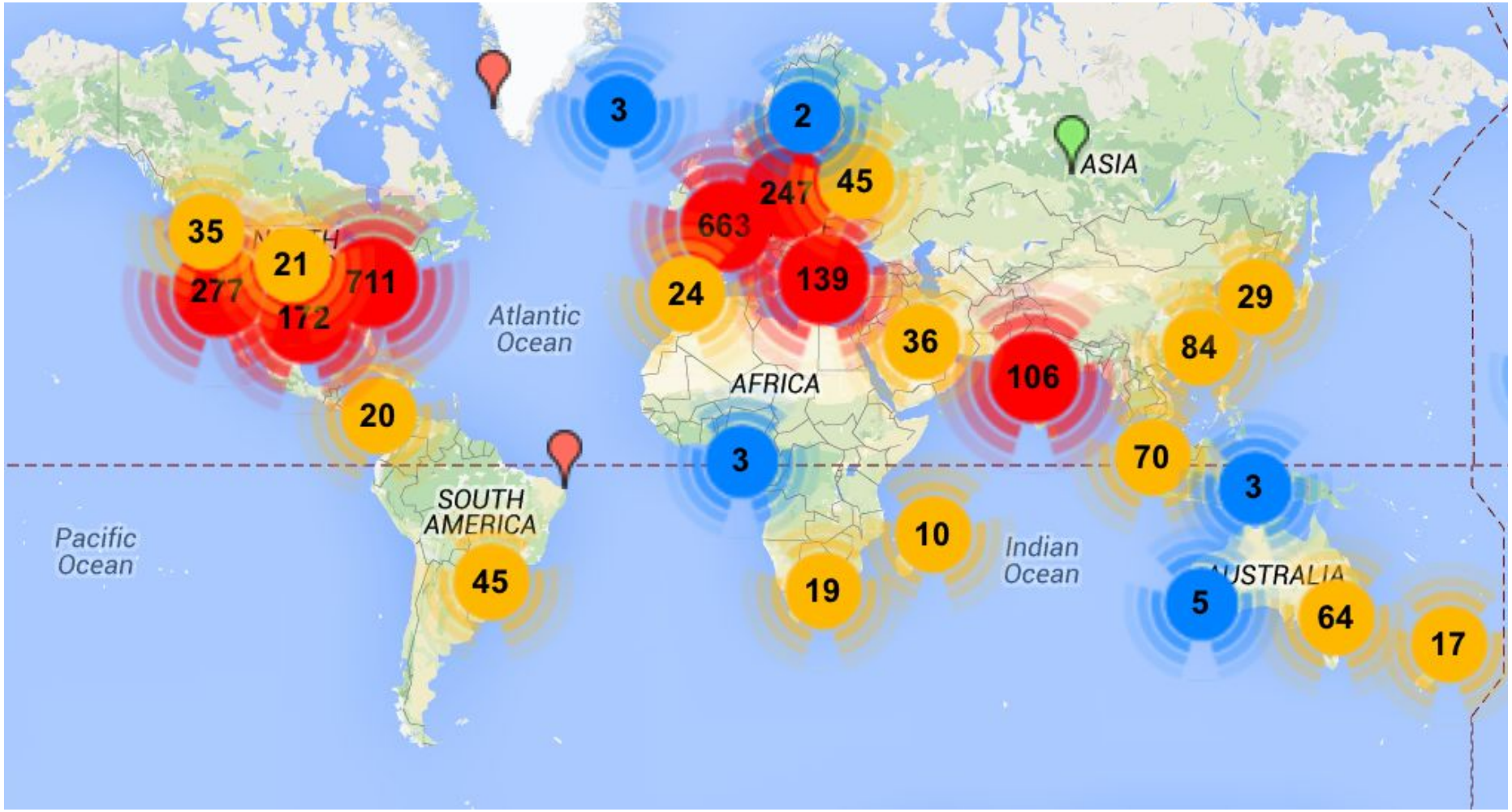
Mapa de Datacenters



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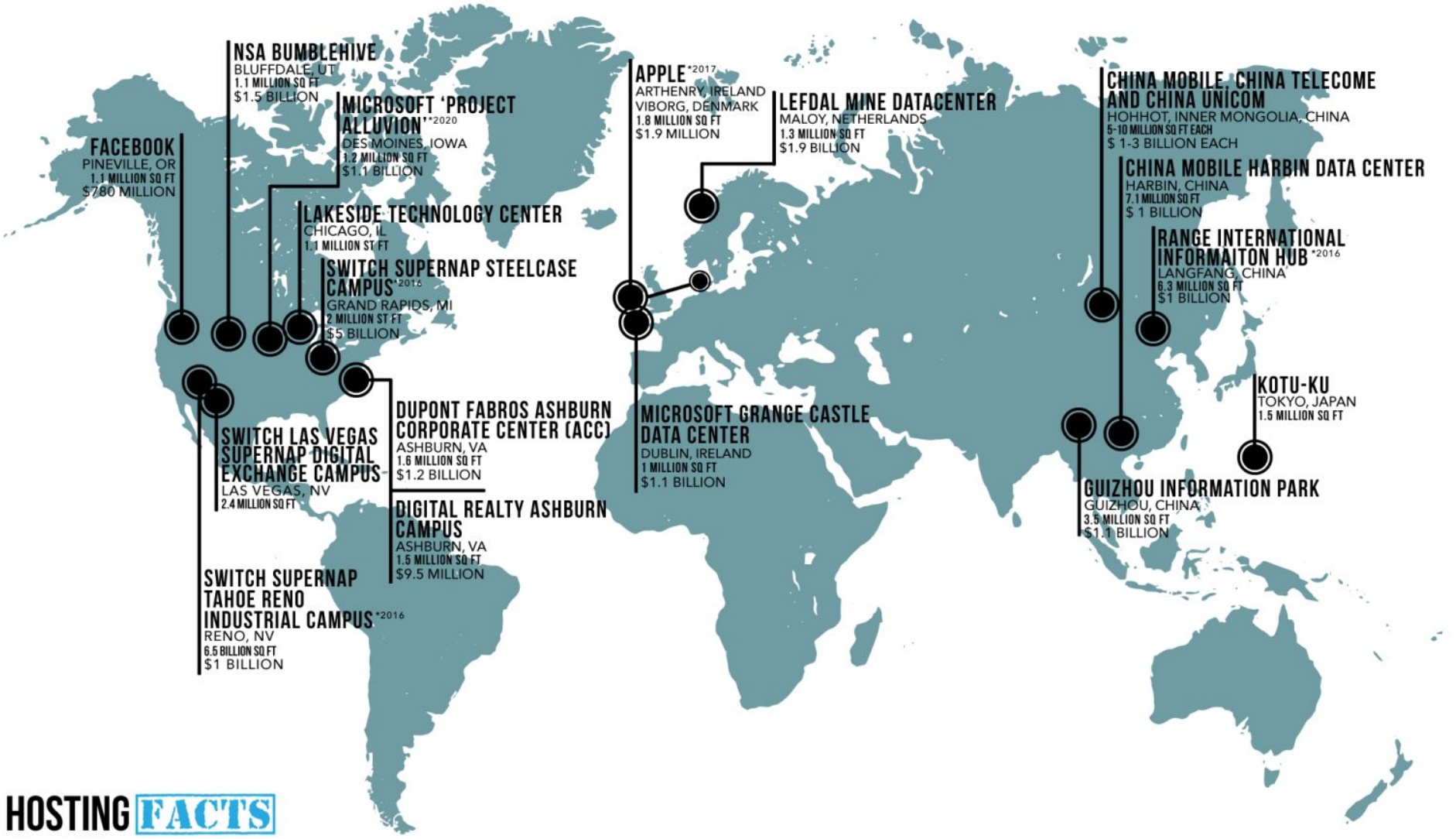
Mapa de Datacenters



HOSTING FACTS

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El Equipo del Tutorial

Marcelo Fernández
17 yrs Telecom (Network Design, Services, Network applications)
NFV/SDN and Orchestration desde 2014
ex Cisco, ENTEL

Gianpietro Lavado
14 yrs Telecom
5 yrs Software
ex Cisco, Global Crossing, Impsat

José Miguel Guzmán
25 yrs Software
20 yrs Telecom
ex Google, ENTEL, Startups

y finalmente,
Staquito!
1 yr en Whitestack

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Agenda

09:30 - 10:00	¿Por qué estamos aquí?
10:00 - 10:15	Movimiento Open Networking
10:15 - 11:00	Software Defined Networks
11:00 - 11:30	Receso
11:30 - 12:15	Network Function Virtualization
12:15 - 13:00	Programabilidad de Redes

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Retos de las redes tradicionales

Retos de las redes tradicionales

OPEX elevado

Horas hombre y número de equipos

CAPEX elevado

Pocas opciones y sin economías de escala

Presión externa

OTTs y crecimiento exponencial del tráfico

Provisión manual

Que requiere especialistas y es susceptible a errores

Equipos de función específica

Construidos para el propósito

Redes complejas

Miles de estándares, baja predictibilidad

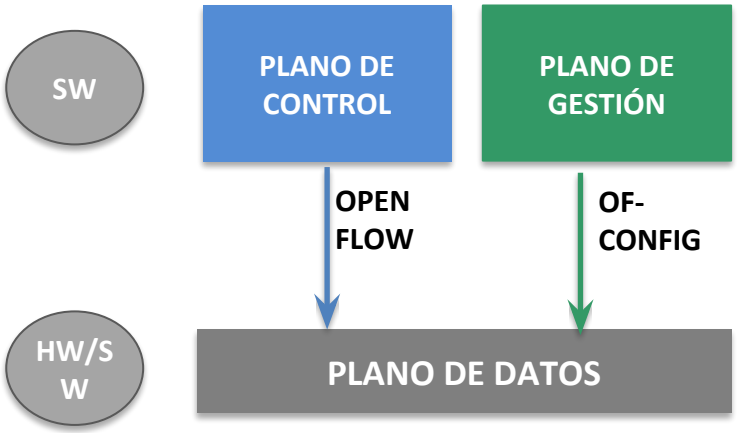
Cuadro Explicativo

OPEN NETWORKING

ONF OPEN NETWORKING FOUNDATION · LINUX FOUNDATION · OPEN Compute Project · ETSI

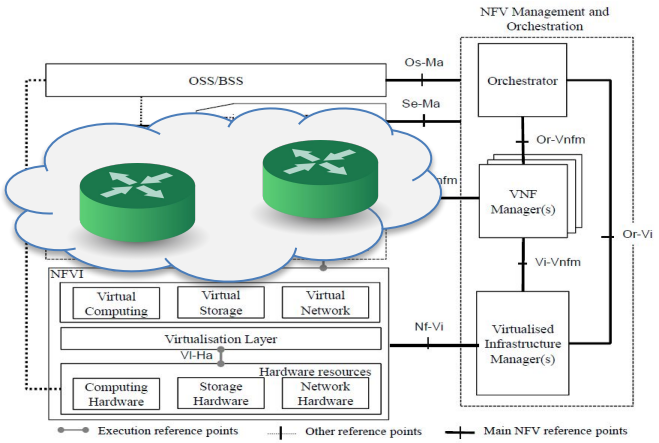
Google · facebook · at&t · verizon · NTT · COMCAST · CISCO · HUAWEI

SOFTWARE DEFINED NETWORKS
Control centralizado vía software



OPEN DAYLIGHT · onos Open Network Operating System · OvS Open vSwitch

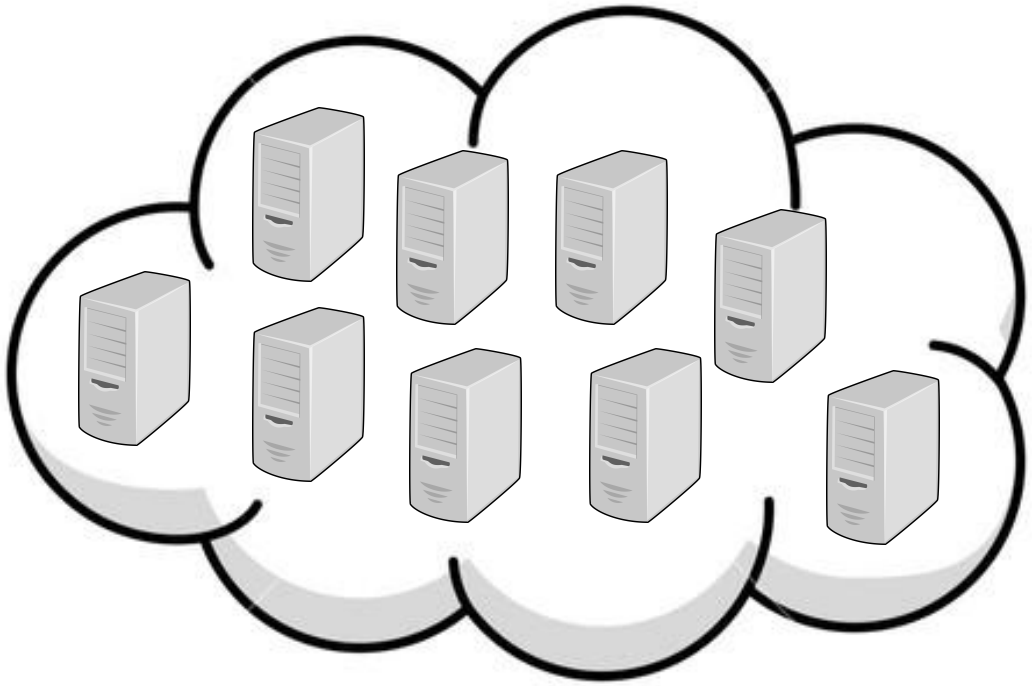
NETWORK FUNCTION VIRTUALIZATION
Virtualización de funciones de red



openstack CLOUD SOFTWARE · Open Source MANO · OPEN BATON · CORD

¿Cómo Conviven?

El cloud motivó la necesidad de las SDN



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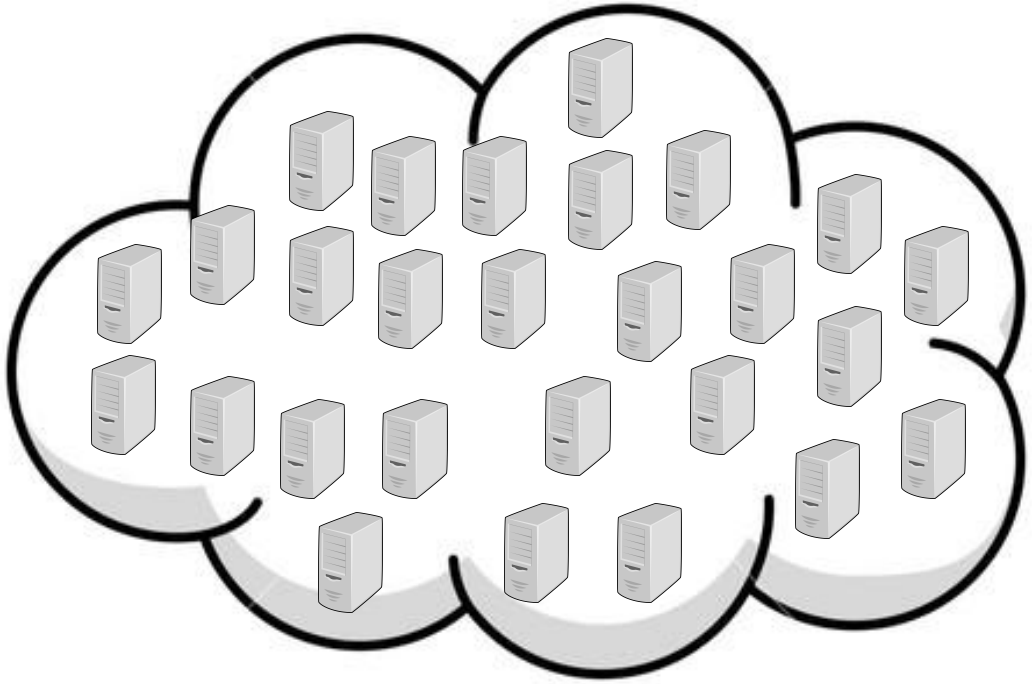
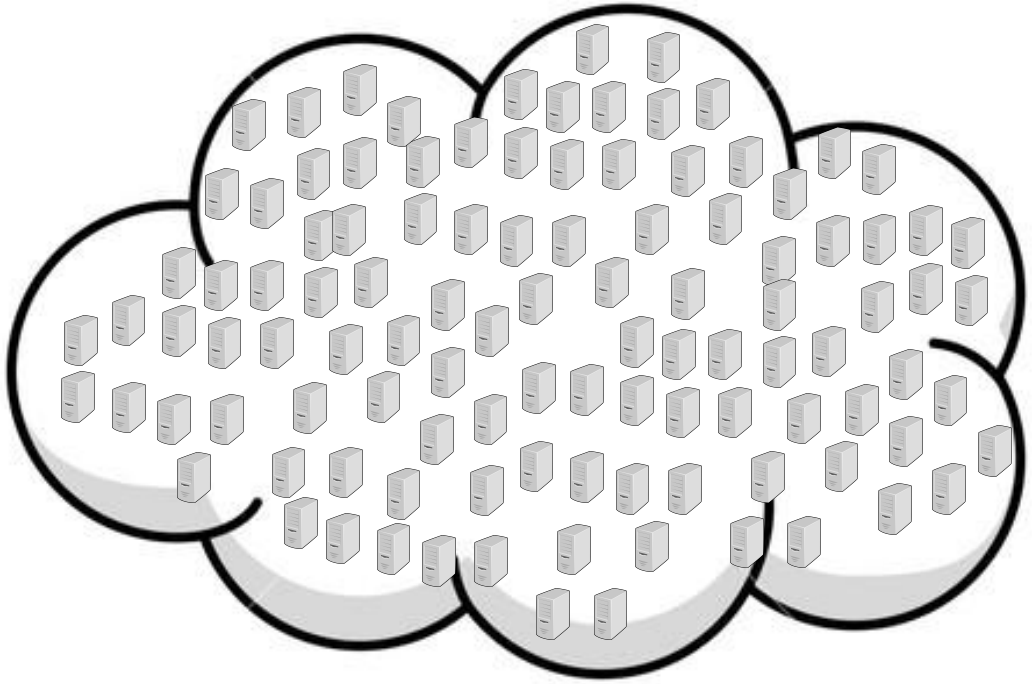


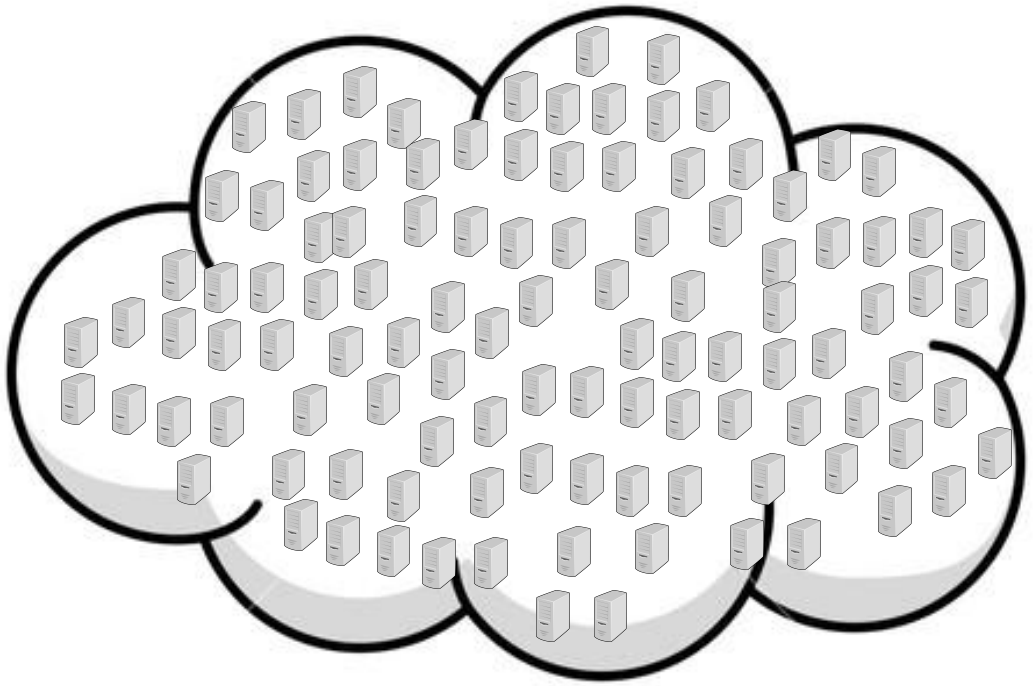
¿Cómo Conviven?

El cloud motivó la necesidad de las SDN



¿Cómo Conviven?

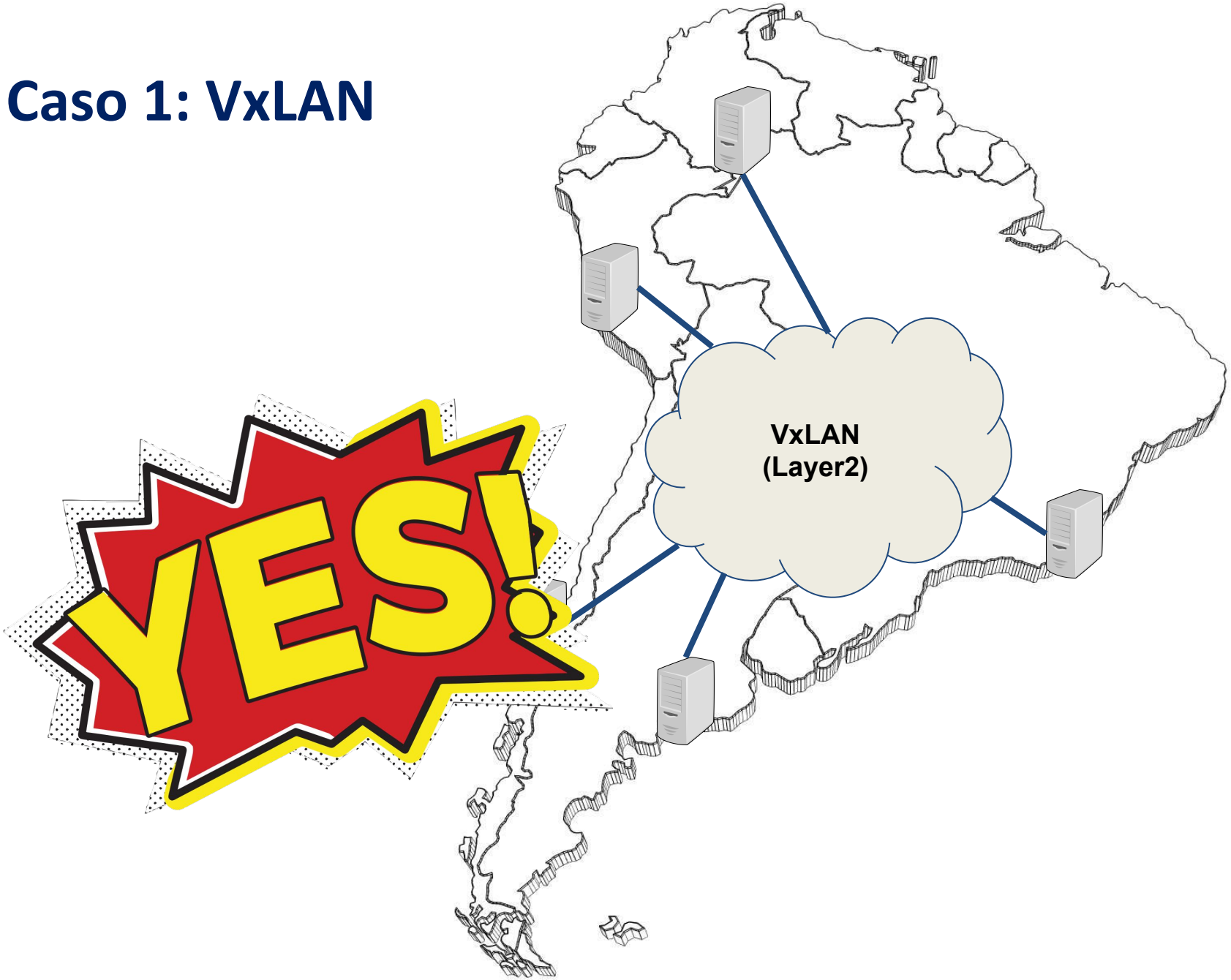
¿Como hago el networking de los cientos / miles de servidores de la nube?



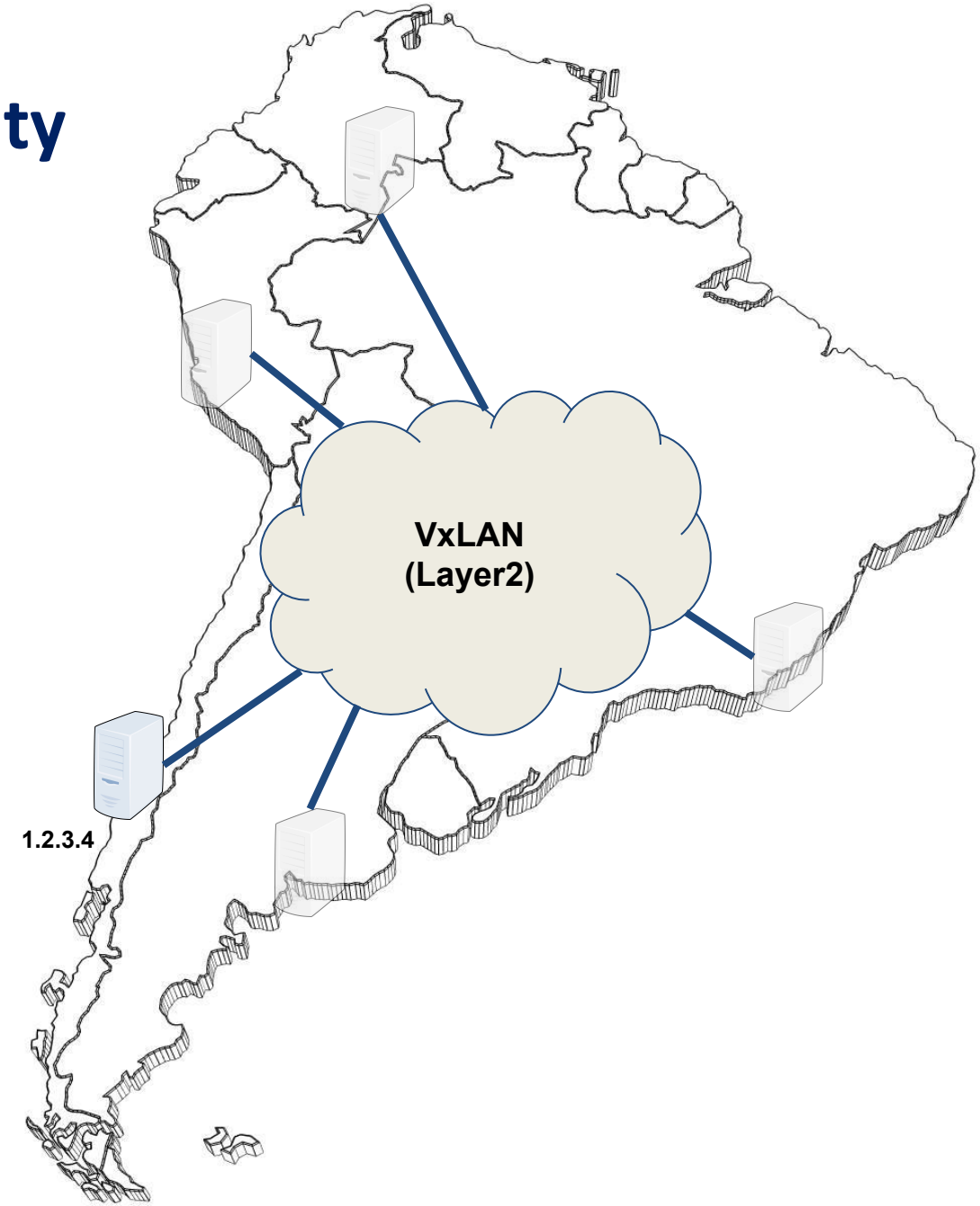
- Alto tráfico
- Alta disponibilidad
- Distintas Ubicaciones
- Múltiples fabricantes
- Re-configuraciones constantes
- Troubleshooting?

Con **Software Defined Networks**

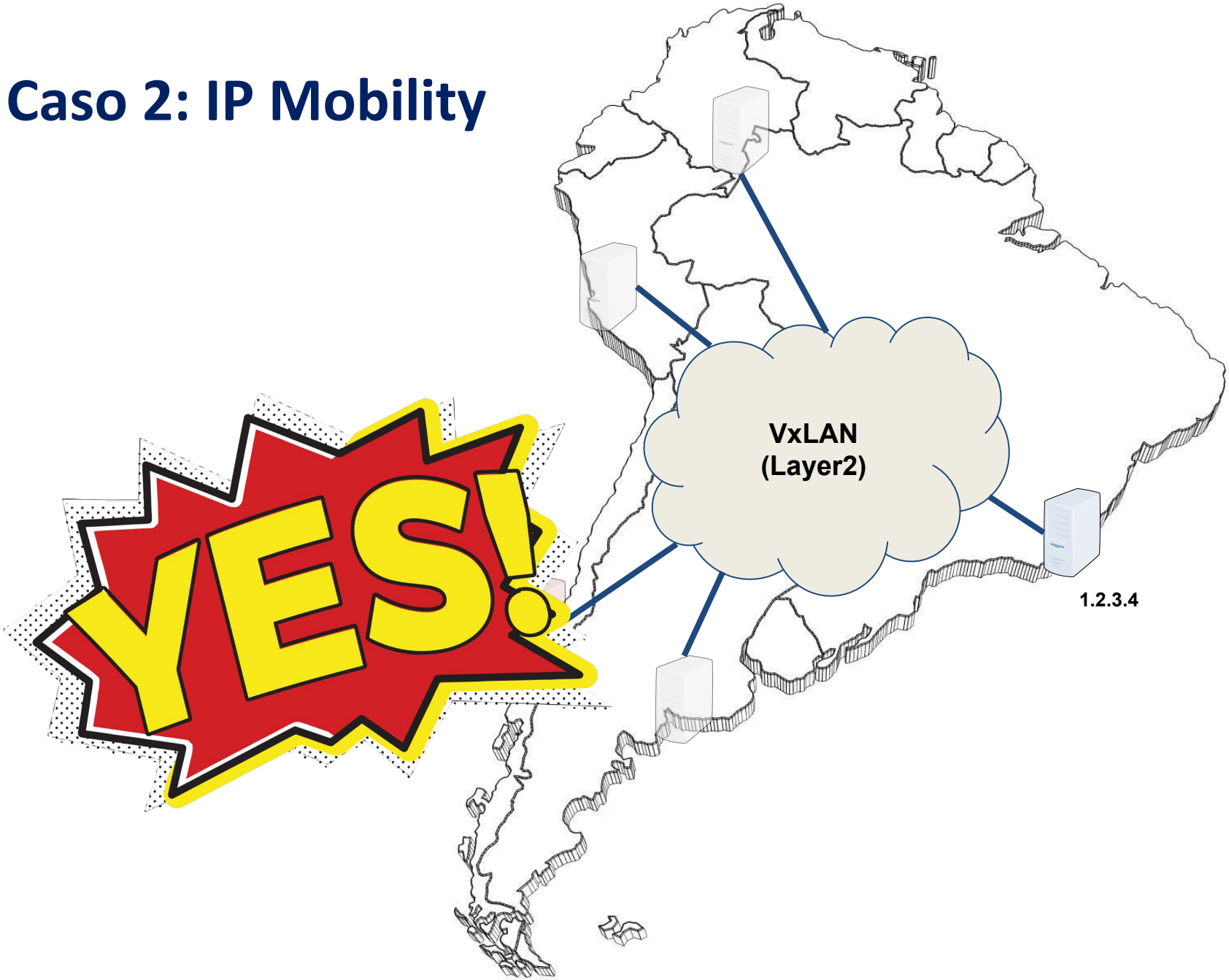
Caso 1: VxLAN



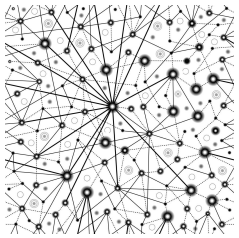
Caso 2: IP Mobility

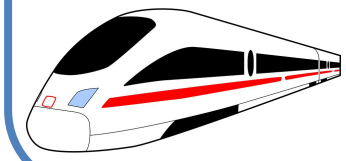


Caso 2: IP Mobility



¿Y Network Function Virtualization?





Cloud

+

SDN

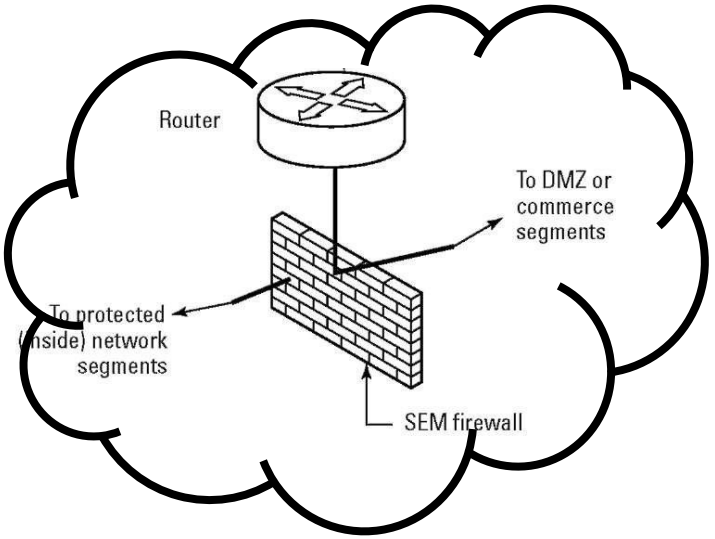
+

Orquestación

+

Performance

= NFV

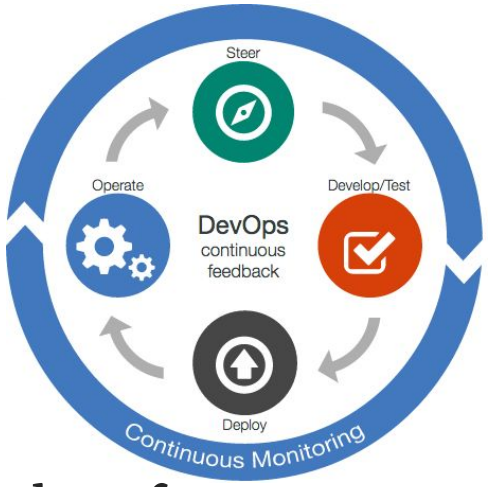


Motivaciones

Motivaciones de SDN

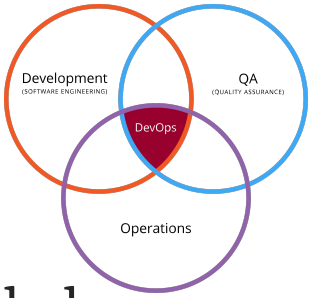
Reducir CAPEX

- Comoditización de Componentes de Red
- Introducir más competencia
- No más “vendor lock-in”



Reducir OPEX

- Simplificar la operación mediante software
- Aplicar técnicas y herramientas del desarrollo de software
- Mantener la red en “versiones” consistentes
- Es decir, **DevOps**



Introducir Agilidad en los Servicios

- Servicios son aplicaciones, que se instalan en Controlador
- Redes programáticas por naturaleza (APIs vs Telnets)
- Servicios que antes no era posible implementar

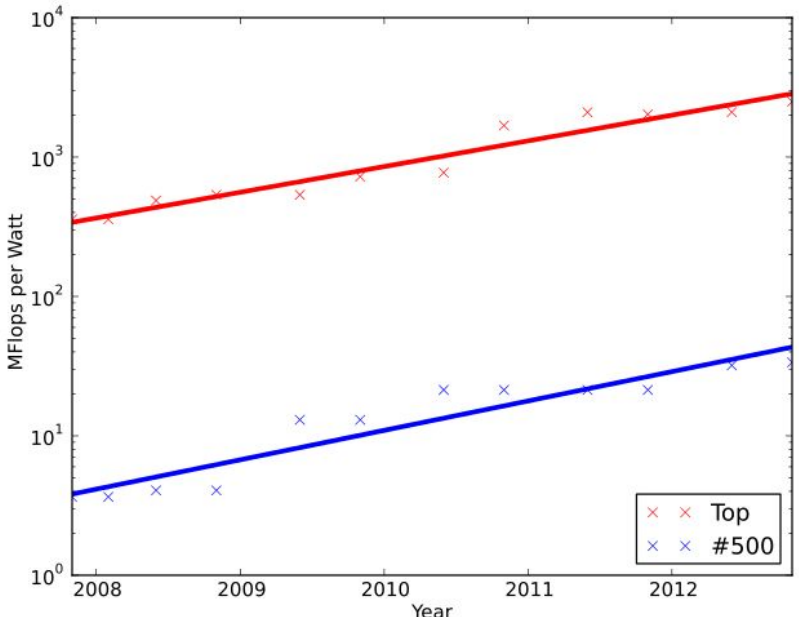
Motivaciones de NFV

Hardware Commodity

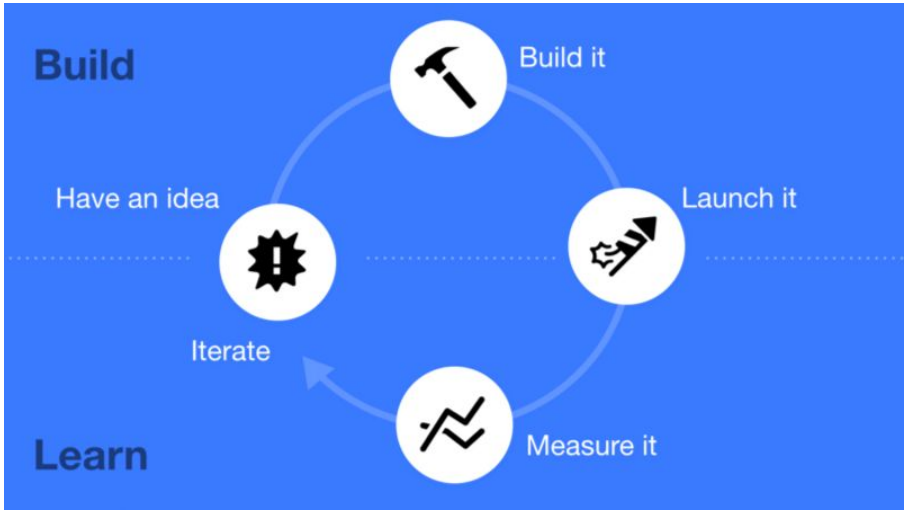
- Servers x86 v/s hardware propietario
- Protección de la inversión

Ahorro en espacio y energía

- Datacenters eficientes alcanzan PUE = 1.09
- MFlops/Watt: 10x en 5 años!



Motivaciones de NFV



Innovación más rápida

- No más “Mega-Proyectos”
- *“Launch & Iterate”*

Asignación Flexible de Recursos

- No más: “No tenemos espacio”

Multiplicidad de Usuarios

(multi-tenancy)

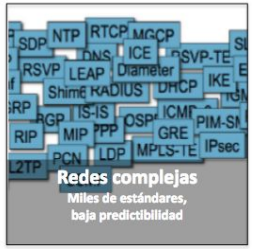
- Particionar la infraestructura, para servir múltiples clientes.

Mayor rentabilidad!

- Evidente mejor “RoI” (Retorno de Inversión)

Resumen: ¿Porqué estamos aquí?

Retos de las redes tradicionales



Como lo está afrontando la Industria:

Open Networking	
SDN	NFV

Motivaciones SDN

- Reducir Capex
- Reducir Opex
- Agilidad de Servicios

Motivaciones NFV

- Hardware Commodity
- Ahorro Espacio y Energía
- Acelerar Innovación
- Asignación flexible de recursos
- Multiplicidad de Usuarios
- Aumentar Rentabilidad

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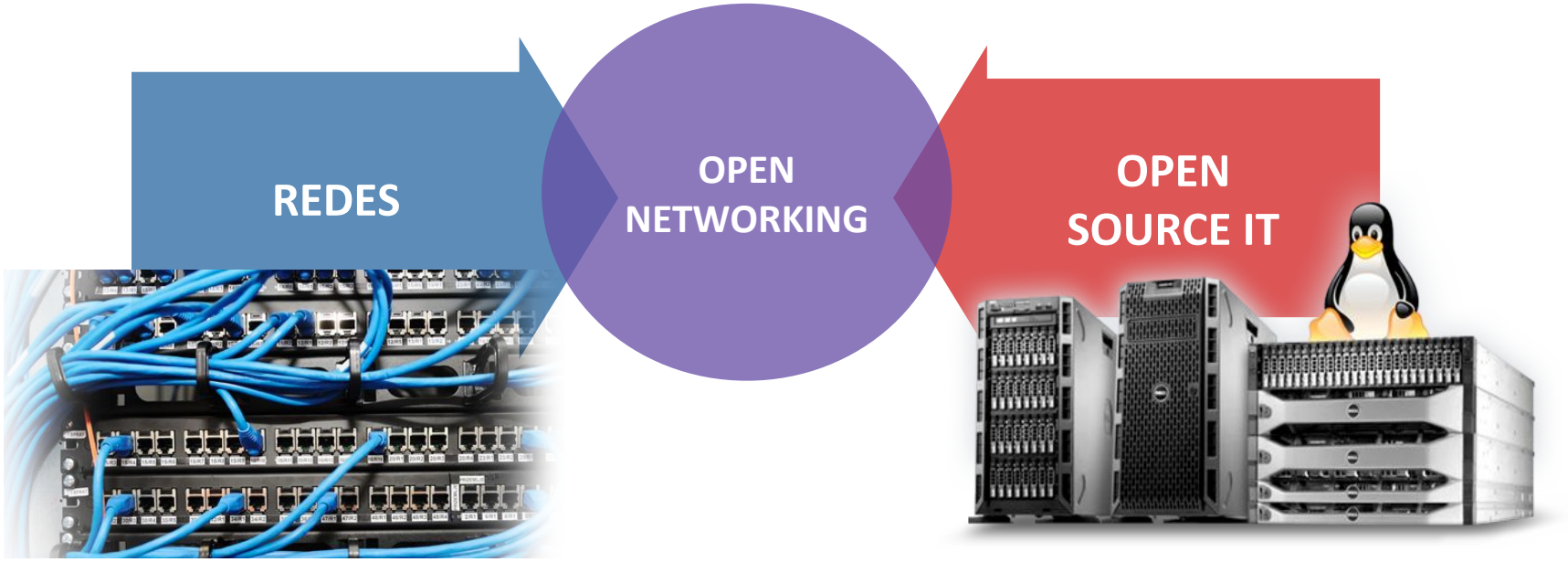
Movimiento *Open Networking*
¿En qué consiste?



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¿Quiénes lo respaldan?

Open Networking Foundation

OPEN NETWORKING FOUNDATION

Open Networking Foundation (ONF) is a user-driven organization dedicated to the promotion and adoption of Software-Defined Networking (SDN) through open standards development.

Proyectos

- OpenFlow
- PROJECT ATRIUM: AN OPEN SOURCE SDN DISTRIBUTION
- SPRING-OPEN PROJECT FOR SEGMENT ROUTING
- ISDX: A SOFTWARE DEFINED INTERNET EXCHANGE POINT
- PROJECT ASPEN: REAL TIME MEDIA INTERFACE SPECIFICATION
- PROJECT DELTA: SDN SECURITY EVALUATION FRAMEWORK

Y más: http://opensourcesdn.org/our-projects

Certificaciones

CERTIFIED SDN ASSOCIATE

CERTIFIED SDN ENGINEER BETA

Miembros

cisco, ciena, T··, CITRIX, Hewlett Packard Enterprise, HUAWEI, facebook, Level(3) COMMUNICATIONS, intel, Google, BROCADE, XILINX, vodafone, 中国电信 CHINA TELECOM, whitestack

Y más: https://www.opennetworking.org/our-members

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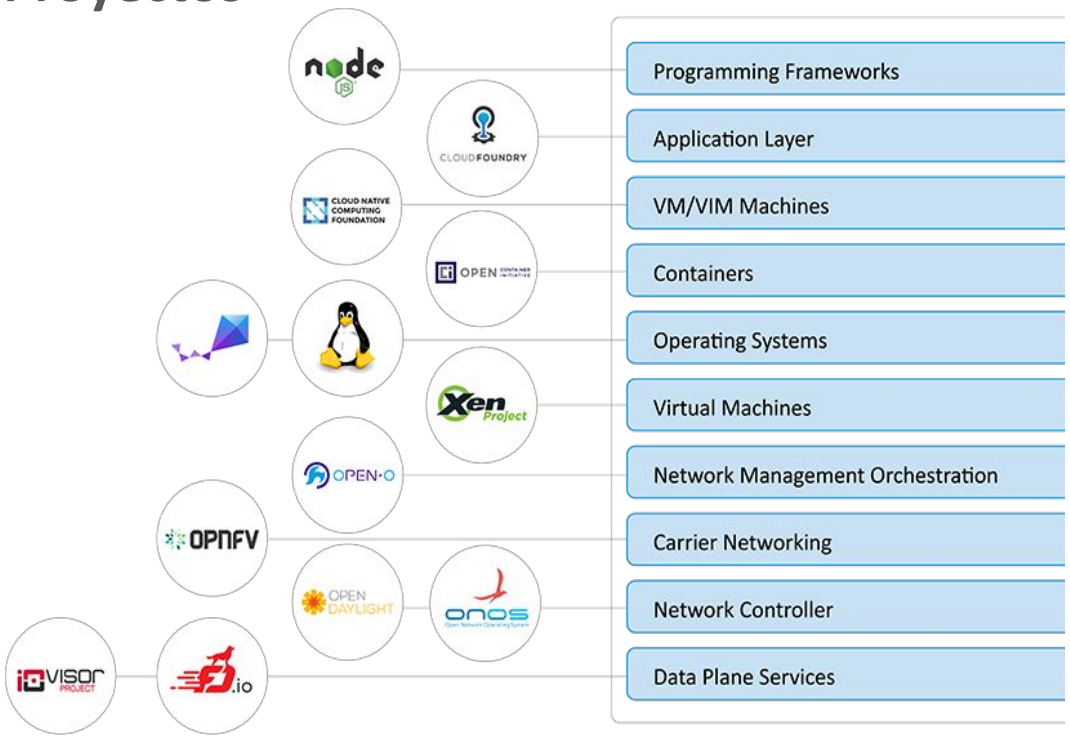
¿Quiénes lo respaldan?
The Linux Foundation

The Linux Foundation partners with the world's leading developers and companies to solve the hardest technology problems and accelerate open technology development and commercial adoption.

Proyectos



Miembros

Y más:
https://www.linuxfoundation.org/members/corporate

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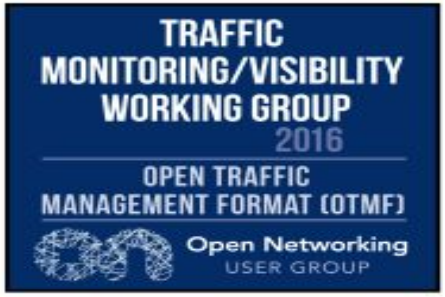
¿Quiénes lo respaldan?

Open Networking User Group

Open Networking
USER GROUP

The ONUG Mission is to enable greater choice and options for IT business leaders by advocating for open interoperable hardware and software-defined infrastructure solutions that span across the entire IT stack, all in an effort to create business value.

Proyectos



Y más: http://opennetworkingusergroup.com/onug-community

Miembros

Bank of America
BNY MELLON
YAHOO!
Morgan Stanley
FedEx
CREDIT SUISSE
citi
JPMorganChase

Y más:
http://opennetworkingusergroup.com/about/

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¿Quiénes lo respaldan?

Open Networking Summit

PROVEEDORES DE SERVICIO | **EMPRESAS** | **FABRICANTES** | **PROYECTOS OPEN SOURCE** | **INVESTIGADORES** | **INVERSIONISTAS**

El más grande evento de *Open Networking*, se discuten los últimos desarrollos en SDN & NFV con impacto significativo al futuro de la industria

Acceso a sesiones y videos del ONS 2016
https://goo.gl/RGSa8M

Próximo evento:
Abril 03 al 06, 2017
Santa Clara, California, US

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Open Networking
Proyectos más relevantes

Estándares abiertos para Data Centers escalables

Algunos de los creadores y desarrolladores:

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Open Networking
Proyectos más relevantes

Servidores con throughput sin precedentes

Algunos de los creadores y desarrolladores:

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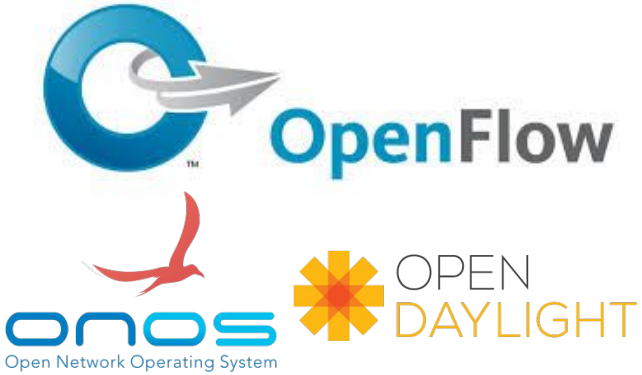
Open Networking
Proyectos más relevantes



Control SDN con nivel para producción

Algunos de los creadores y desarrolladores:

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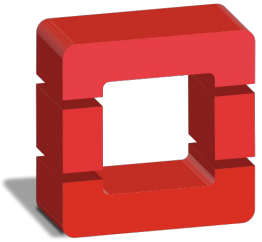
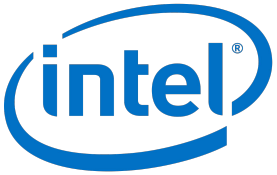
Open Networking
Proyectos más relevantes



Clouds automatizados y escalables al alcance de todos

Algunos de los creadores y desarrolladores:



redhat

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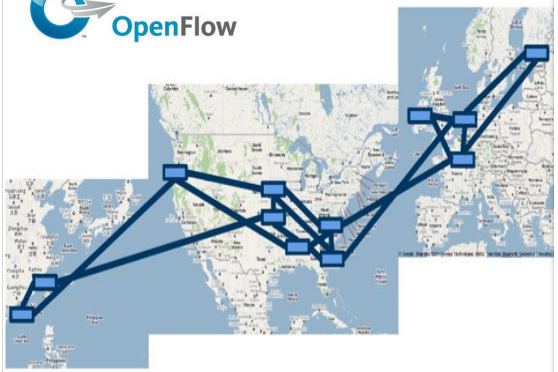
¿Es real?
Algunos ejemplos...

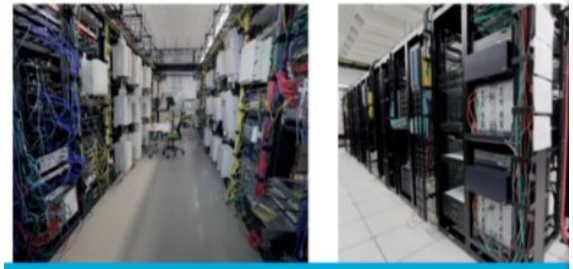
Google

OpenFlow



- La primera WAN SDN
- Capacidad aprovechada al 100%

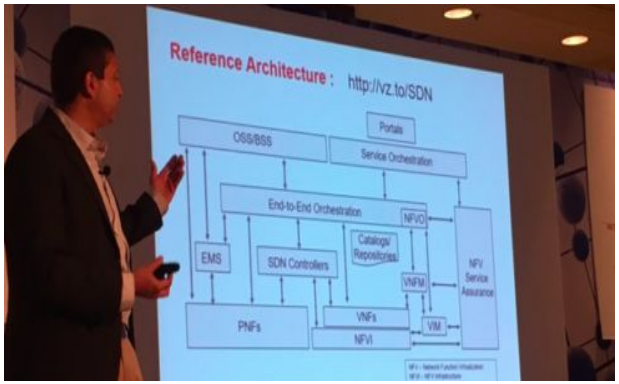
AT&T



openstack CLOUD SOFTWARE · CORD Central Office Re-architected as a Datacenter · ONOS Open Network Operating System · OPEN DAYLIGHT

- Plan agresivo de virtualiza
- NFV al 70% en el 2020

verizon



openstack CLOUD SOFTWARE · OPEN DAYLIGHT · ONOS Open Network Operating System

- Arquitectura de referencia SDN/NFV
- Software + *WhiteBoxes*

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¿Es real?

Algunos ejemplos...

COMCAST

COMCAST BUSINESS

B4B

BUILT FOR BUSINESS™

- "Software Defined L3VPI sin utilizar MPLS
- Fuerte usuario de Open Daylight y OpenStack

facebook

- Operan su propio hardwa sistema SDN
- Fundadores del Open Compute Project

Goldman Sachs

Cisco CEO Pressured by Goldman Sachs to Embrace Software

openstack CLOUD SOFTWARE

OPEN DAYLIGHT

OpenFlow

- Presionando a fabricantes en favor de SDN, adoptado hace ~10 años a su manera
- Board del ONF

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Open Networking
Proyectos más relevantes

Descarga nuestro ***poster*** → https://goo.gl/2UKVxh

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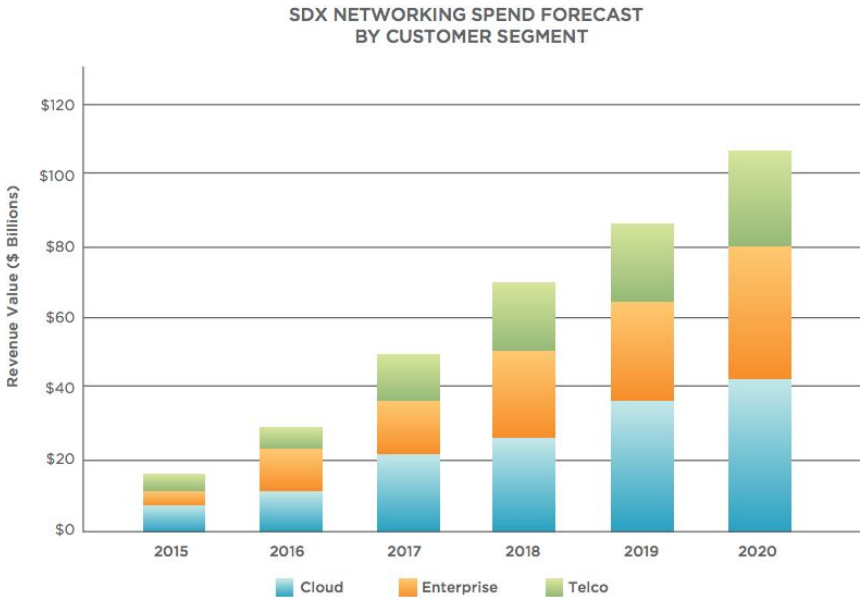
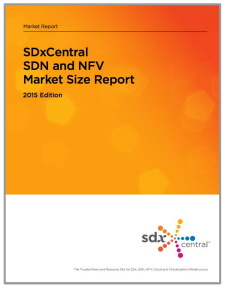
Software Defined Networking
¿Qué tanta tracción?

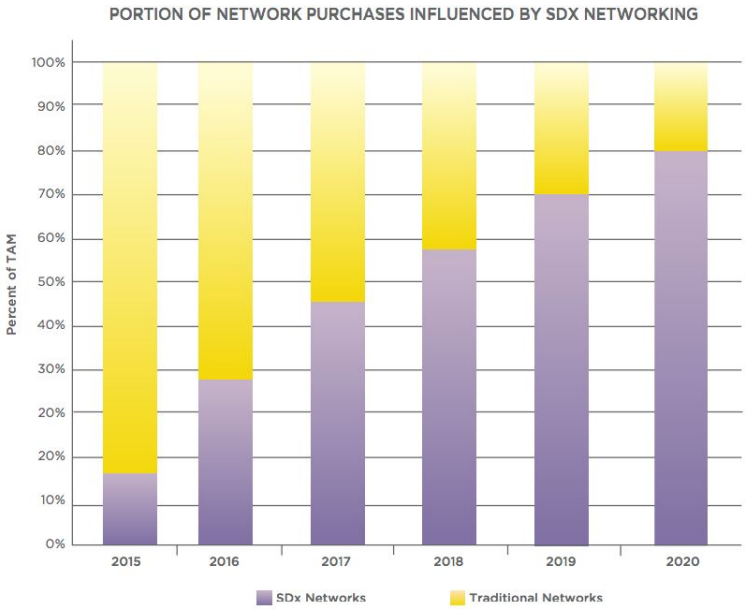




SDxCentral SDN & NFV
Landscape Report 2015

¡ $100B para el 2020 !
Cloud > Enterprise > Telco

SDN → ¡80% de la inversión en redes para el 2020!



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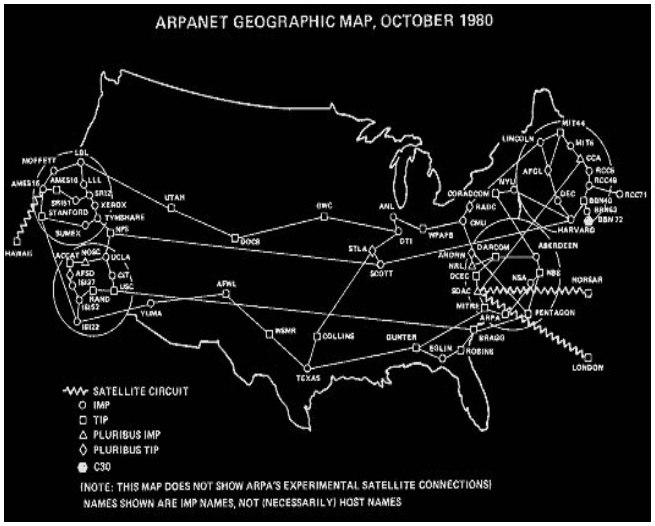
Software Defined Networking

Los orígenes: ¿cómo debería ser el Internet?

1980

Las organizaciones administraban un router

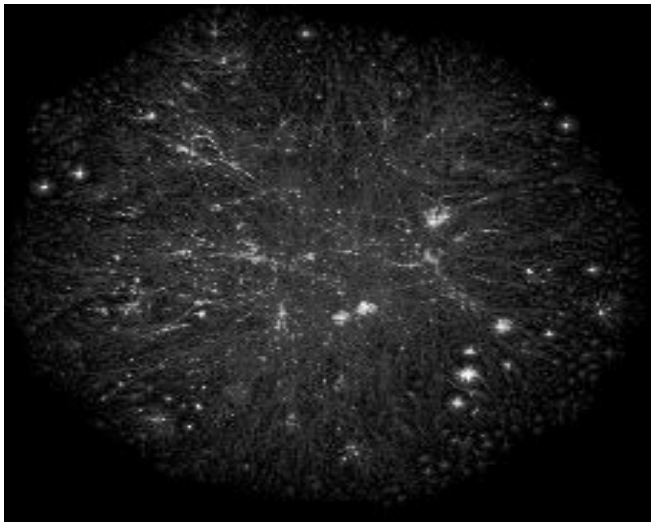
- Cada router es un sistema autónomo
- Debe determinar a su propio riesgo como encaminar paquetes (protocolos de enrutamiento)
- Implementaciones complejas.



20xx

Las organizaciones administran redes de routers

- La red en conjunto es un sistema autónomo.
- Las implementaciones se vuelven más ineficientes.
- Se requiere una abstracción de los elementos para operar una sola red.



En TI, este nuevo nivel de abstracción se llama **Cloud**, una forma eficiente de operar granjas de servidores

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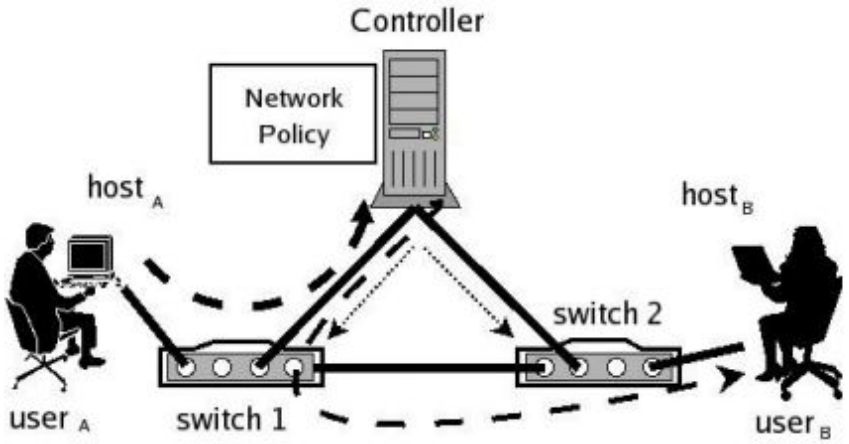
Software Defined Networking

Los orígenes: ¿cómo debería ser el Internet?

Conclusión: Proyecto "***Clean Slate Design for the Internet***" → **Ethane (2009)**

(Stanford High-Performance Networking research group)

Un controlador de red centralizado basado en software, que configure reglas para los flujos en los switches.



Ethane: taking control of the enterprise
Martin Casado et al, Fall 2009

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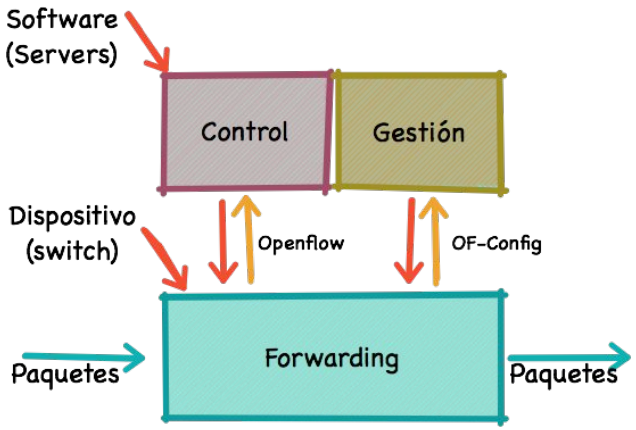
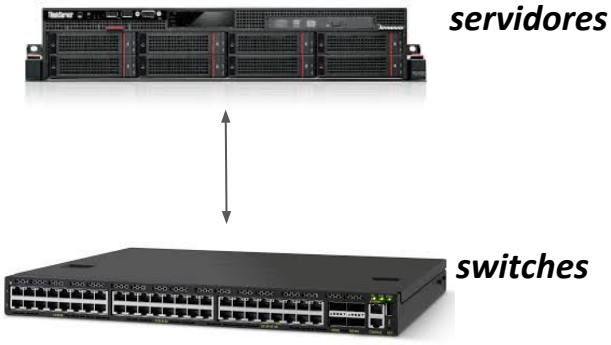
Software Defined Networking
¿De qué se trata?

Red tradicional	Red definida por Software (SDN)
Plano de control y forwarding en el mismo dispositivo	Plano de control desacoplado y compartido por la capa de *forwarding*
Control vía comandos (CLI)	Control programático (principalmente Openflow / OF-Config)





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Software Defined Networking

Elementos

Componente	Descripción	Ejemplos
Plano de control y gestión	• Controladores SDN en alta disponibilidad • Abstraen información de la red hacia aplicaciones contenidas que definen el comportamiento de la misma. • Las aplicaciones no requieren conocer los protocolos o topología y comúnmente exponen APIs (*northbound*) • Corren en servidores (reales o virtuales - *Cloud*)	OPEN DAYLIGHT ONOS Open Network Operating System Floodlight
Protocolo o *Southbound API*	• El protocolo de comunicación utilizado entre el controlador y el plano de datos.	OpenFlow NET CONF BGP PCEP
Plano de datos (*forwarding*)	• Equipamiento genérico (*whitebox*) con soporte de Openflow especializado en encaminar paquetes a alta velocidad.	PICA8 WHITE BOX SDN hp NEC

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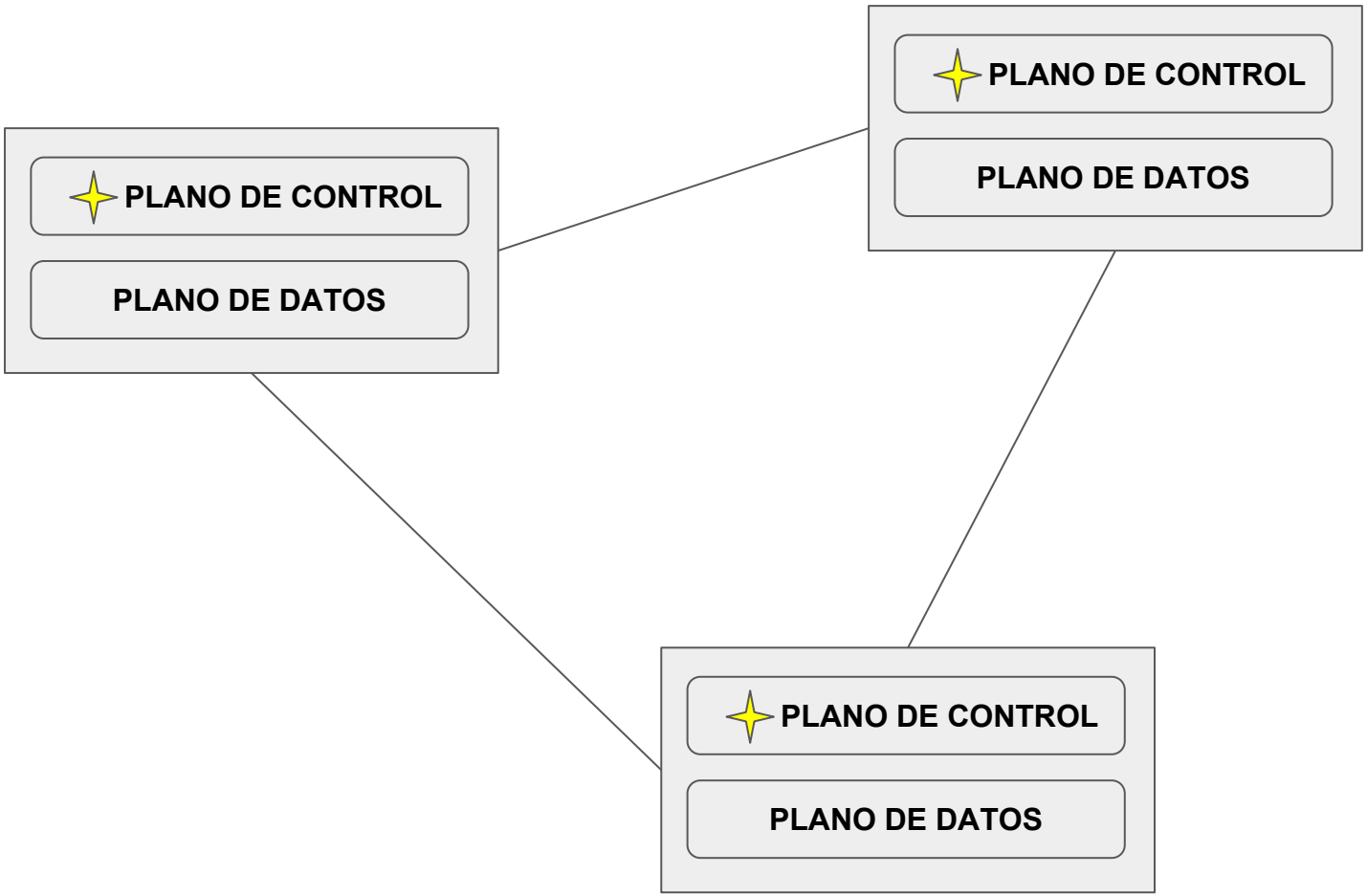
Software Defined Networking

¿Cómo se compara con lo existente?

valor agregado



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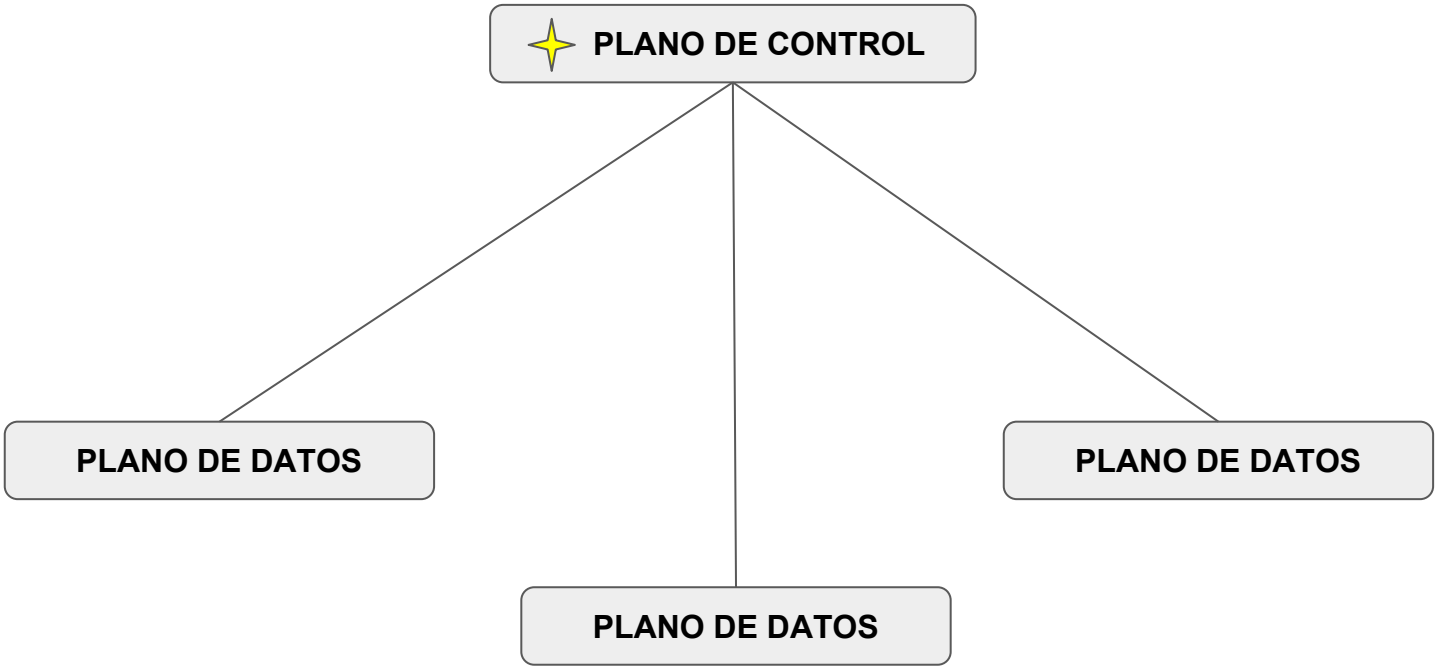
Software Defined Networking

¿Cómo se compara con lo existente?

- valor agregado



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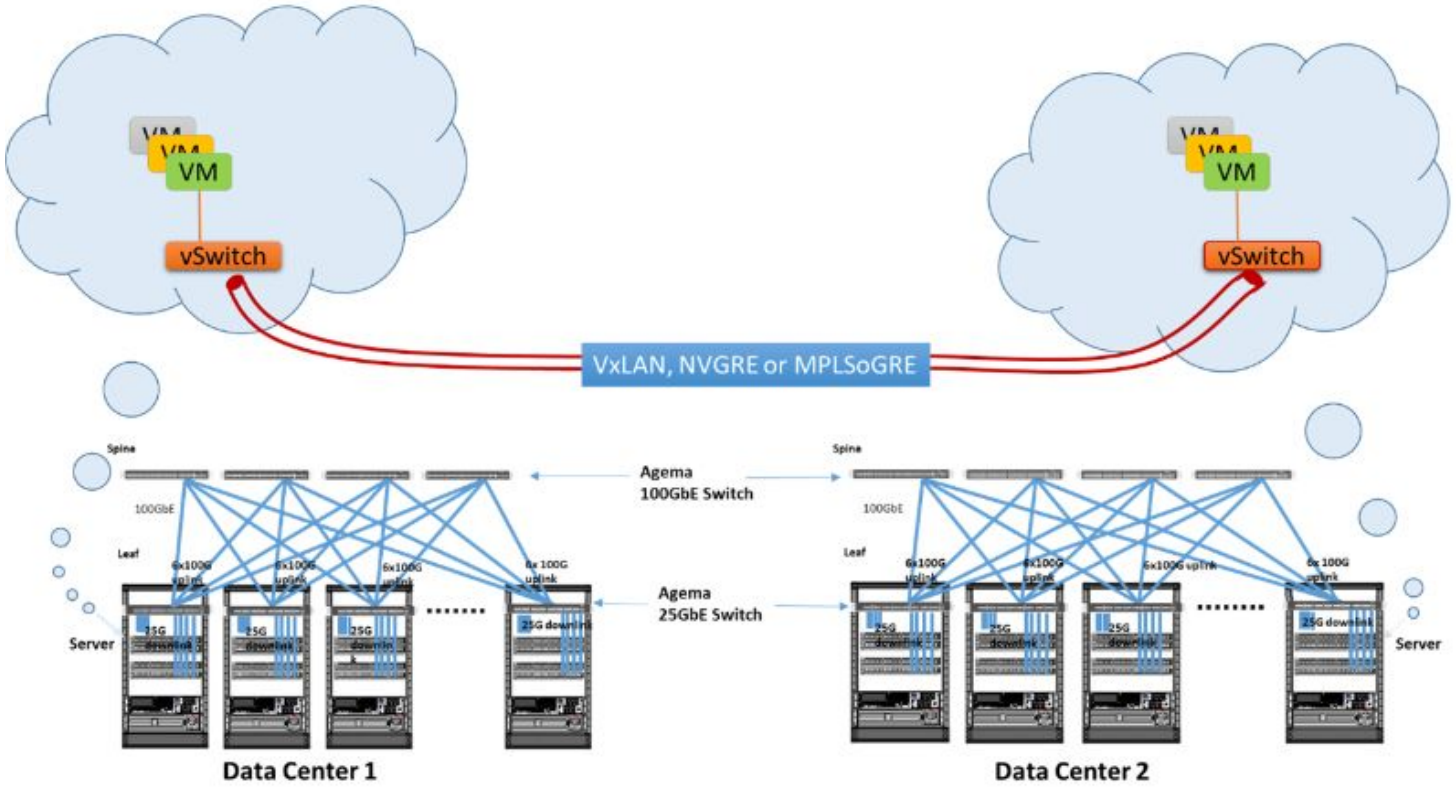
Software Defined Networking

¿Requiero cambiar toda la red?

No! de hecho, se puede empezar de inmediato utilizando el concepto “SDN Overlay”



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Ejemplo Southbound API → OPENFLOW
Hitos importantes

- **2009** - Standford publica la especificación OF 1.0.0
- **2009** - Nicira invierte en desarrollo
- **2010** - Big Switch invierte en desarrollo
- **2011** - Se crea la **Open Network Foundation**
- **2012** - Google anuncia migración de parte de su red a Openflow → https://www.youtube.com/watch?v=VLHJUfgxEO4

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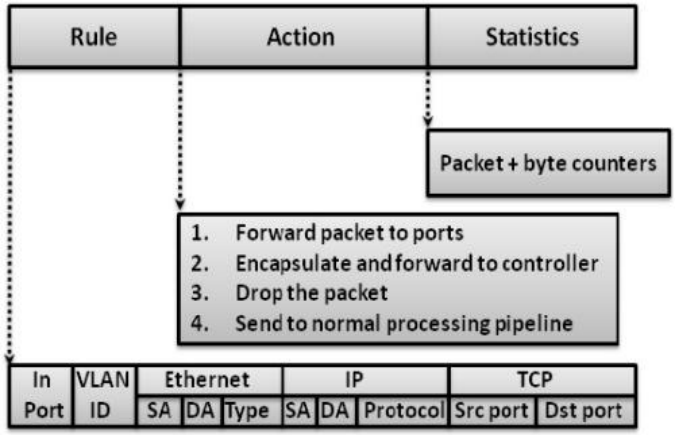
Ejemplo Southbound API → OPENFLOW
¿Cómo funciona?

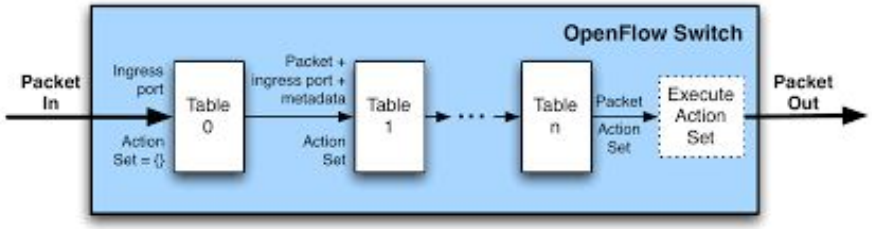
Flujos

El controlador implementa reglas de *match* y acciones de encaminamiento que alimentan las tablas.



Pipeline

Los paquetes se evalúan en tablas y el switch ejecuta acciones



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Ejemplo Southbound API → OPENFLOW
¿Cómo funciona?

Un mismo switch Openflow puede implementar cualquier función de red (aplicaciones). Ejemplos:

Switching

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport	Action
*	*	00:1f:..	*	*	*	*	*	*	*	port6

Flow Switching

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport	Action
port3	00:2e..	00:1f..	0800	vlan1	1.2.3.4	5.6.7.8	4	17264	80	port6

Firewall

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport	Forward
*	*	*	*	*	*	*	*	*	22	drop

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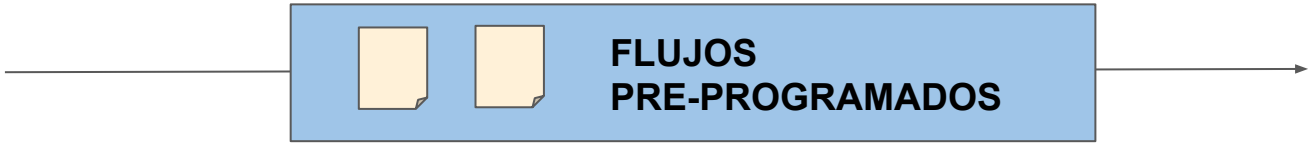
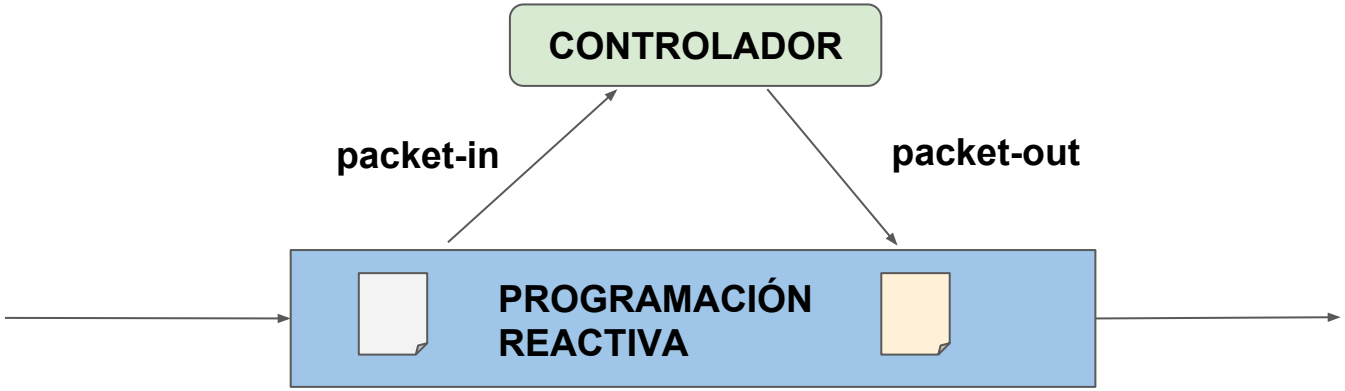
Ejemplo Southbound API → OPENFLOW
Otros conceptos relevantes

Proactive Openflow



Reactive Openflow (escalabilidad?)



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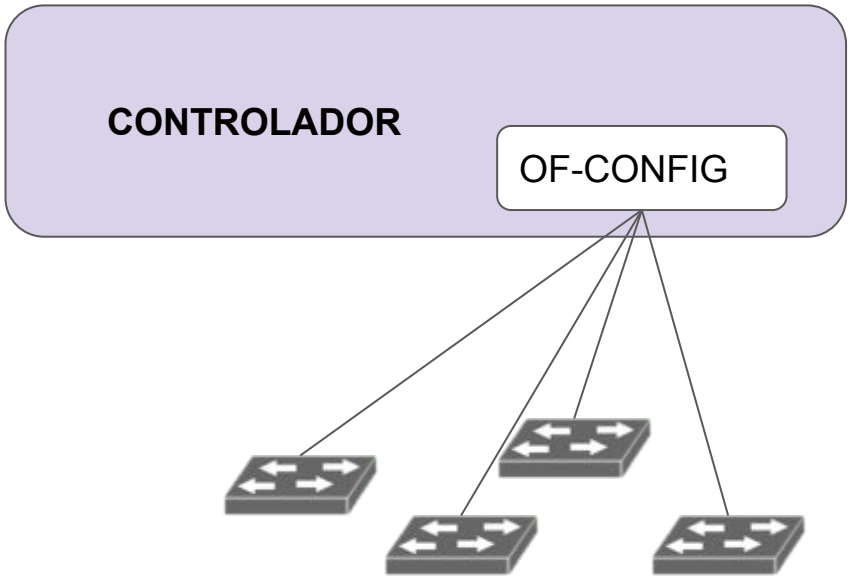
Ejemplo Southbound API → OPENFLOW
Otros conceptos relevantes

OF-Config

Configura los recursos lógicos del switch Openflow. Utiliza el protocolo Netconf (RFC 6241)



Ejemplos:

- descubre recursos
- administra puertos
- obtiene estado del switch

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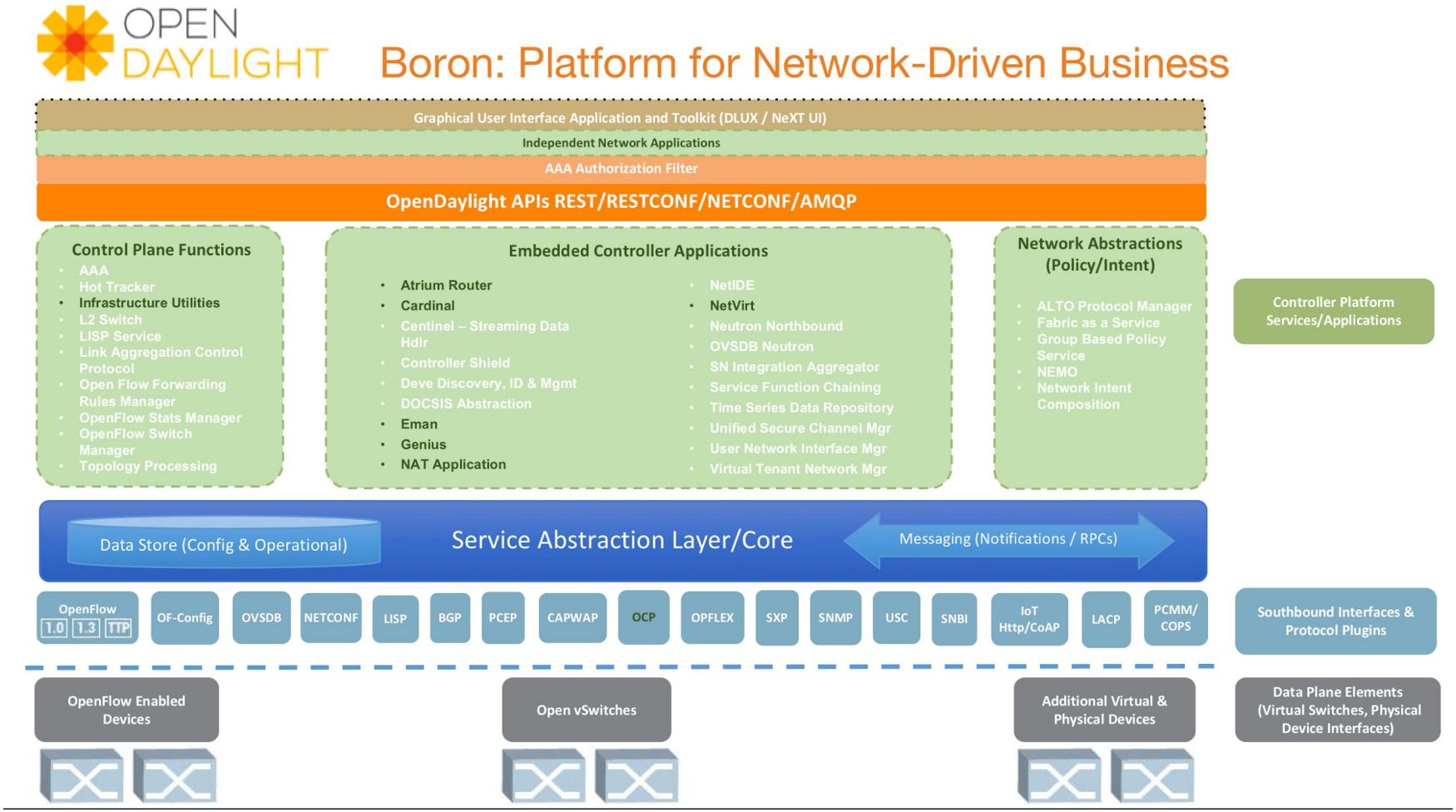
Ejemplo de Controlador → Open Daylight Arquitectura

https://www.opendaylight.org/odlboron



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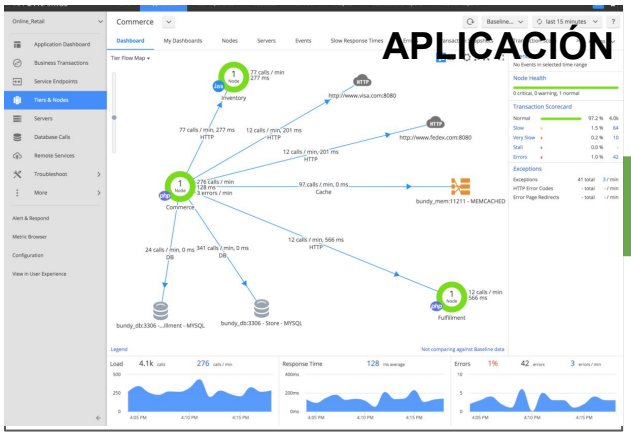
¡ Vamos al lab !

Controlando una red SDN - Intro

Aplicación → Controlador Open Daylight → Red Programable



NB API

CONTROLADOR SDN

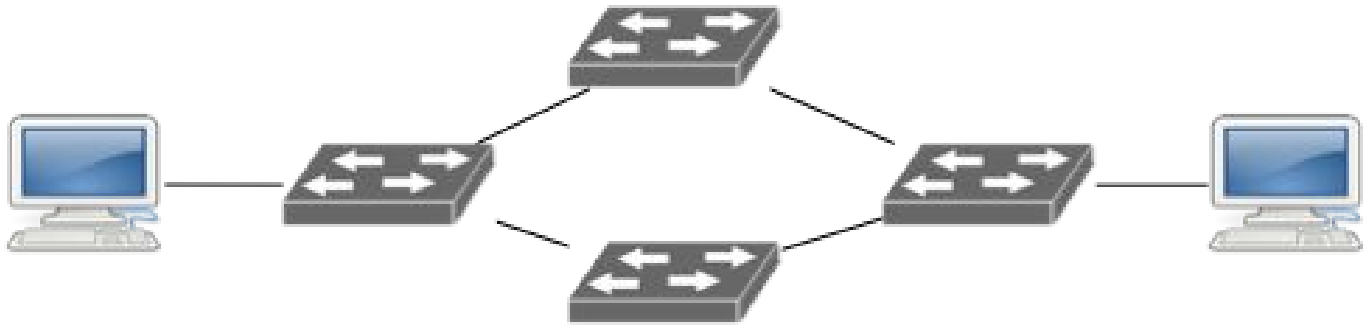
ONOS Open Network Operating System

OPEN DAYLIGHT

Floodlight

Southbound API

RED



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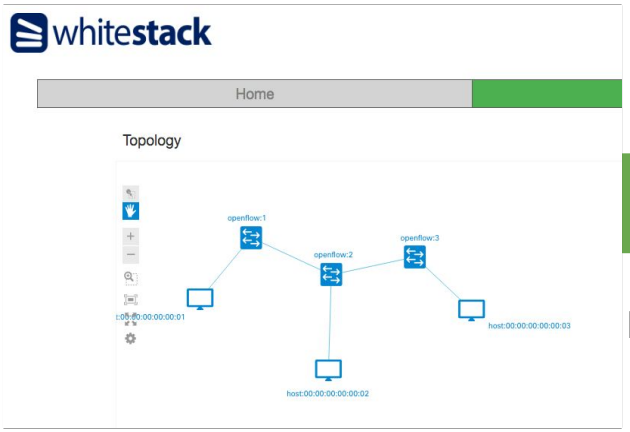
¡ Vamos al lab !

Controlando una red SDN - Lab

Aplicación ⟶ Controlador Open Daylight ⟶ Red Programable



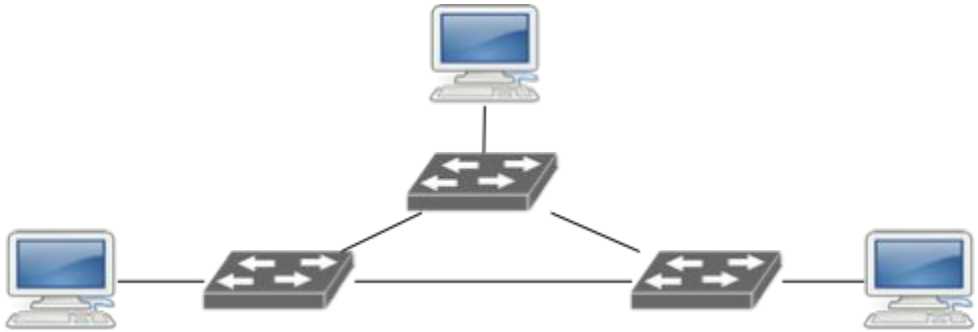
REST API

Beryllium release

OPEN DAYLIGHT

OPENFLOW

MININET



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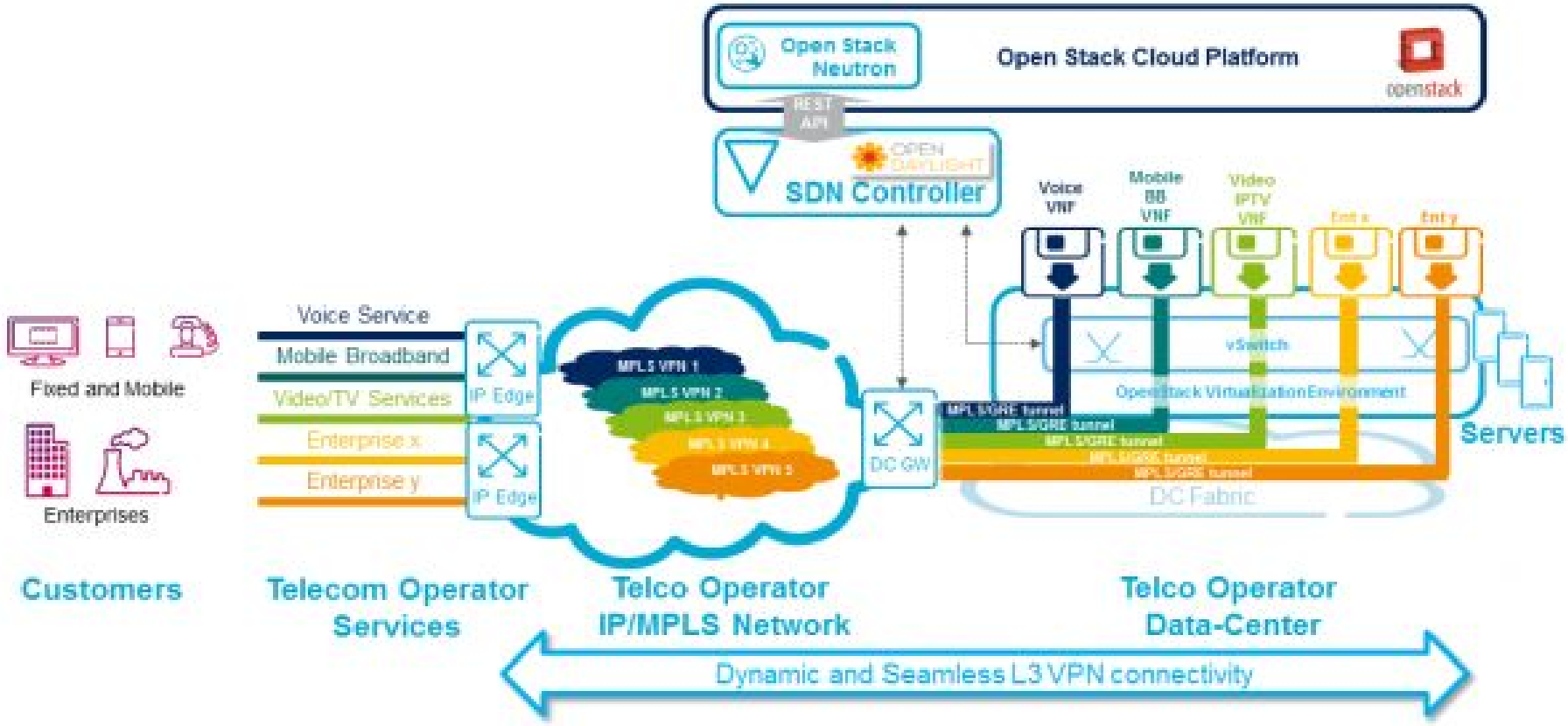
¡ Vamos al lab !

Controlando una red SDN - Caso real

OpenStack → Open Daylight → NFV Service Chains



AT&T's Network On Demand Services

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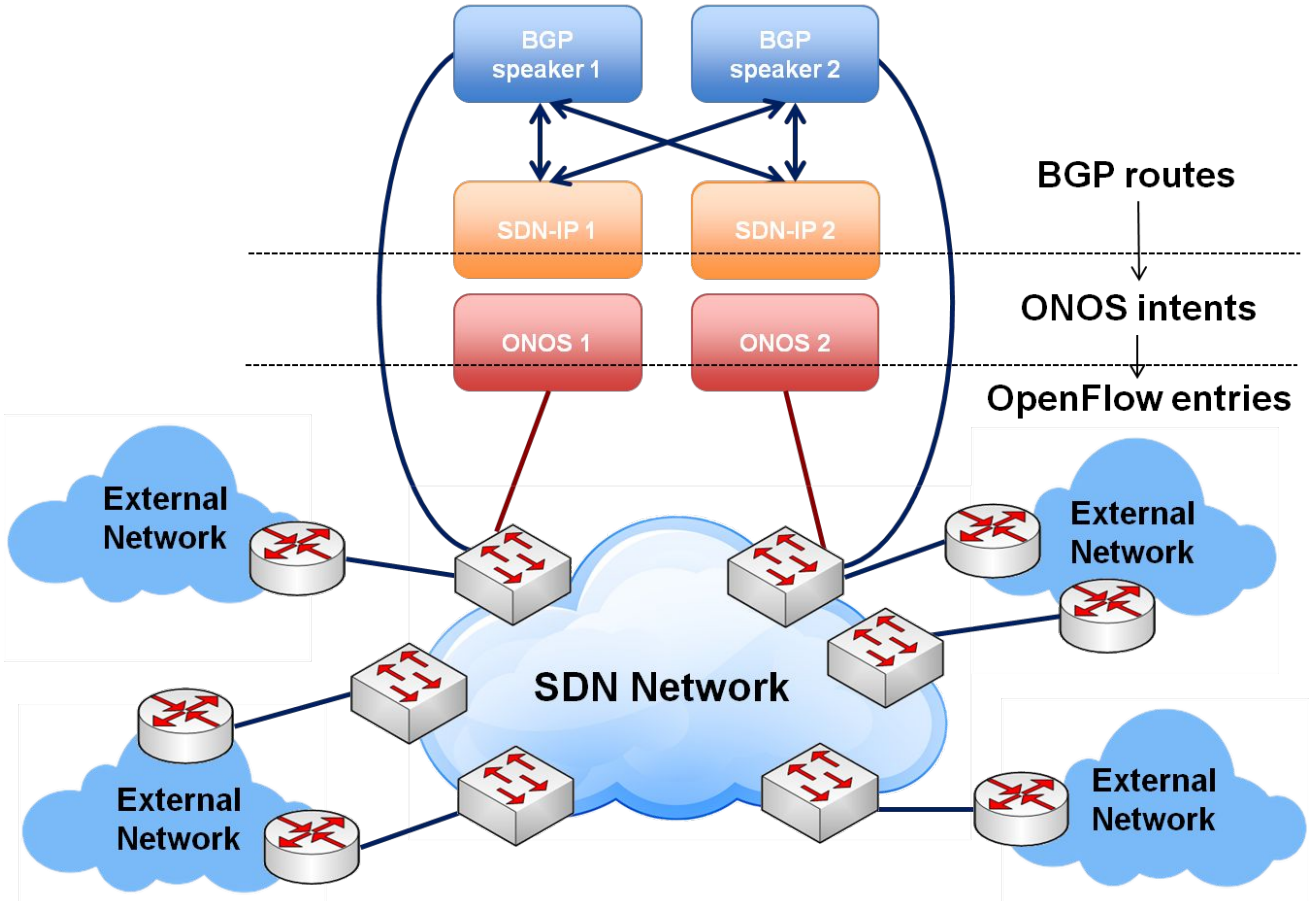
¡ Vamos al lab !

Interconectando SDN con IP - Intro

ONOS SDN-IP - Router SDN distribuido como como tránsito de sistemas autónomos



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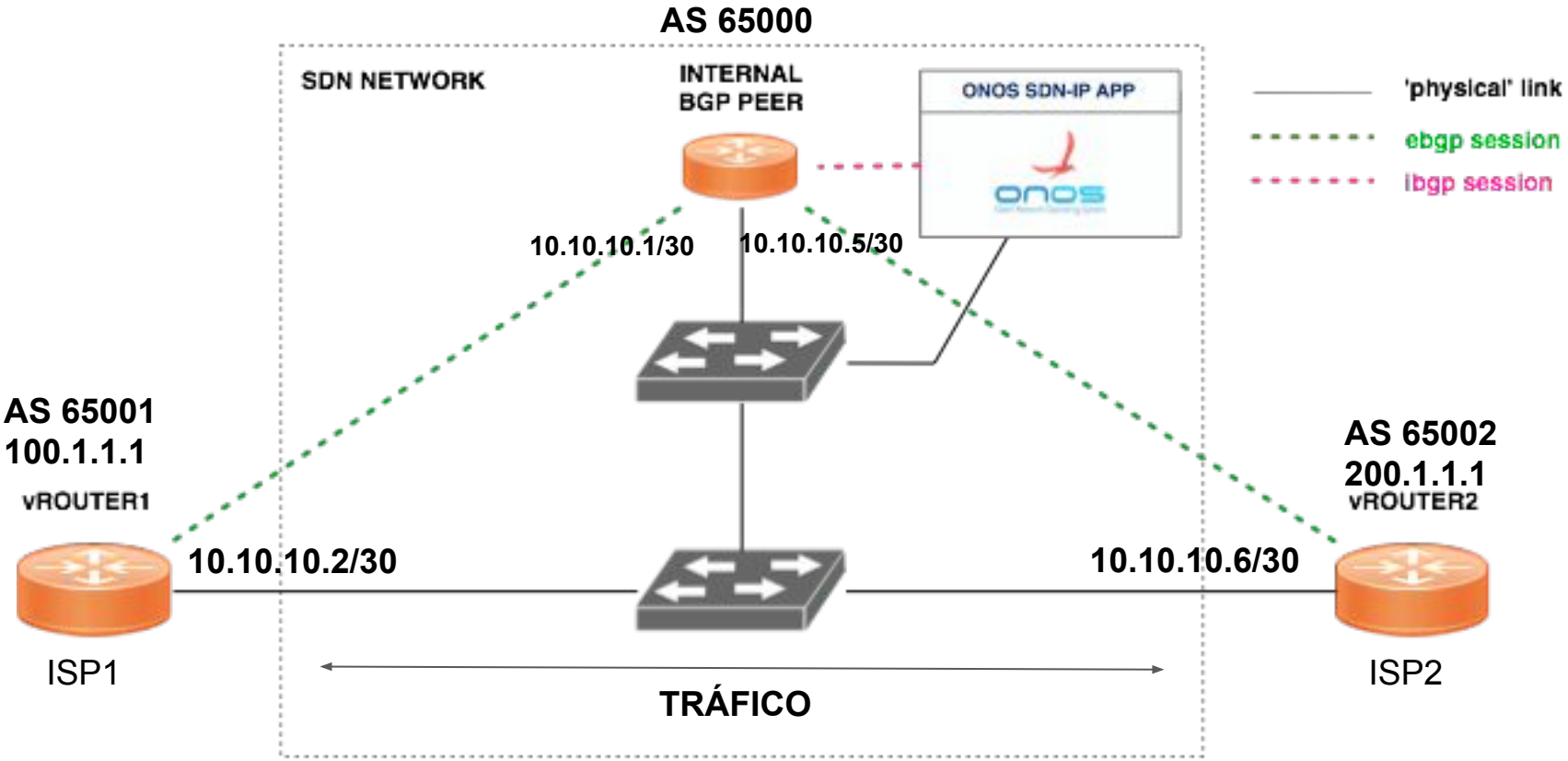
¡ Vamos al lab !

Interconectando SDN con IP - Lab

Red 1 tradicional ⟷ Red SDN ⟷ Red 2 tradicional



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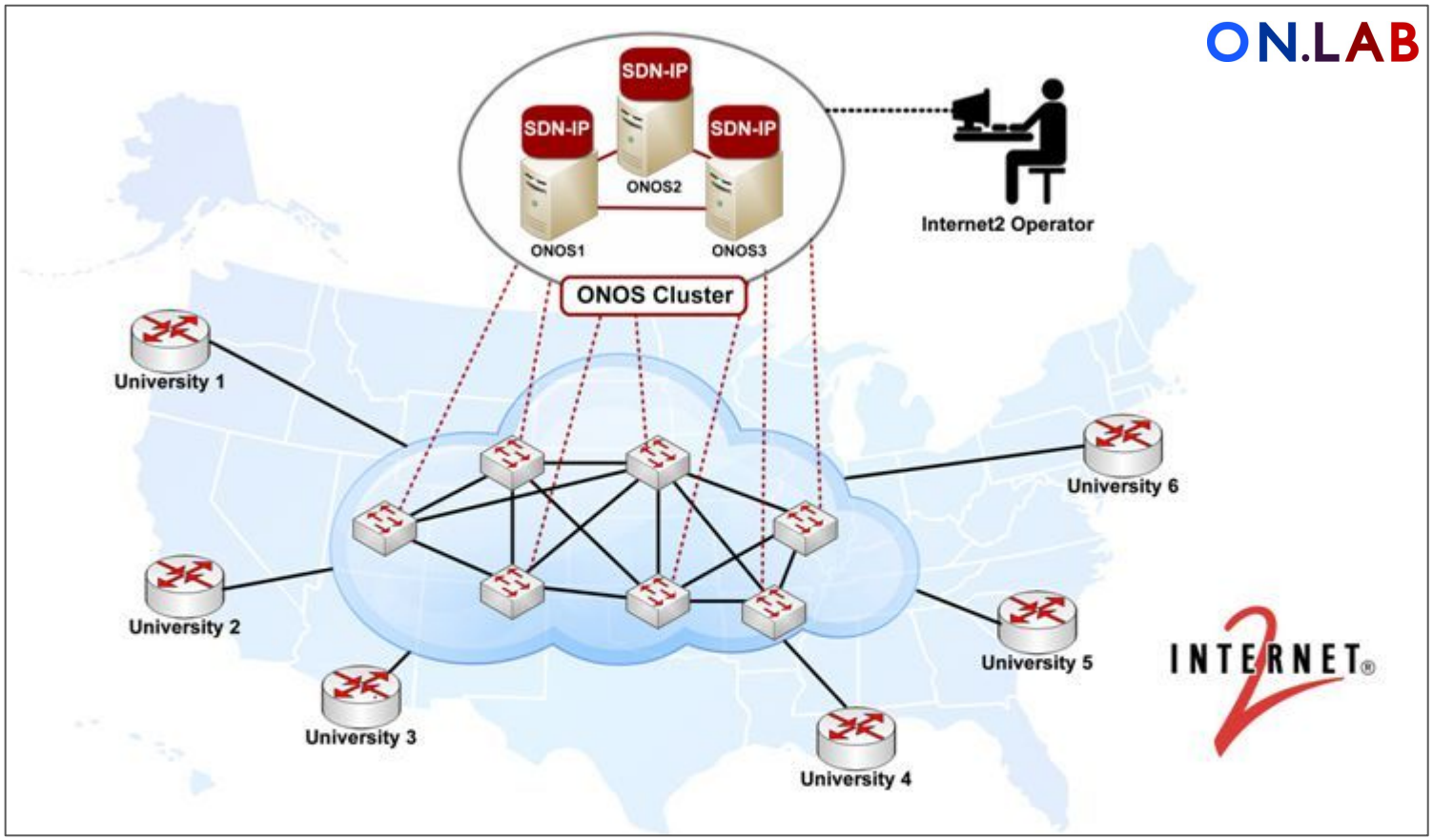
¡ Vamos al lab !

Interconectando SDN con IP - Caso real

Red de Internet2 - Core SDN-IP para la interconexión de *peers* BGP



Más información: http://onosproject.org/wp-content/uploads/2015/06/PoC_global-deploy.pdf

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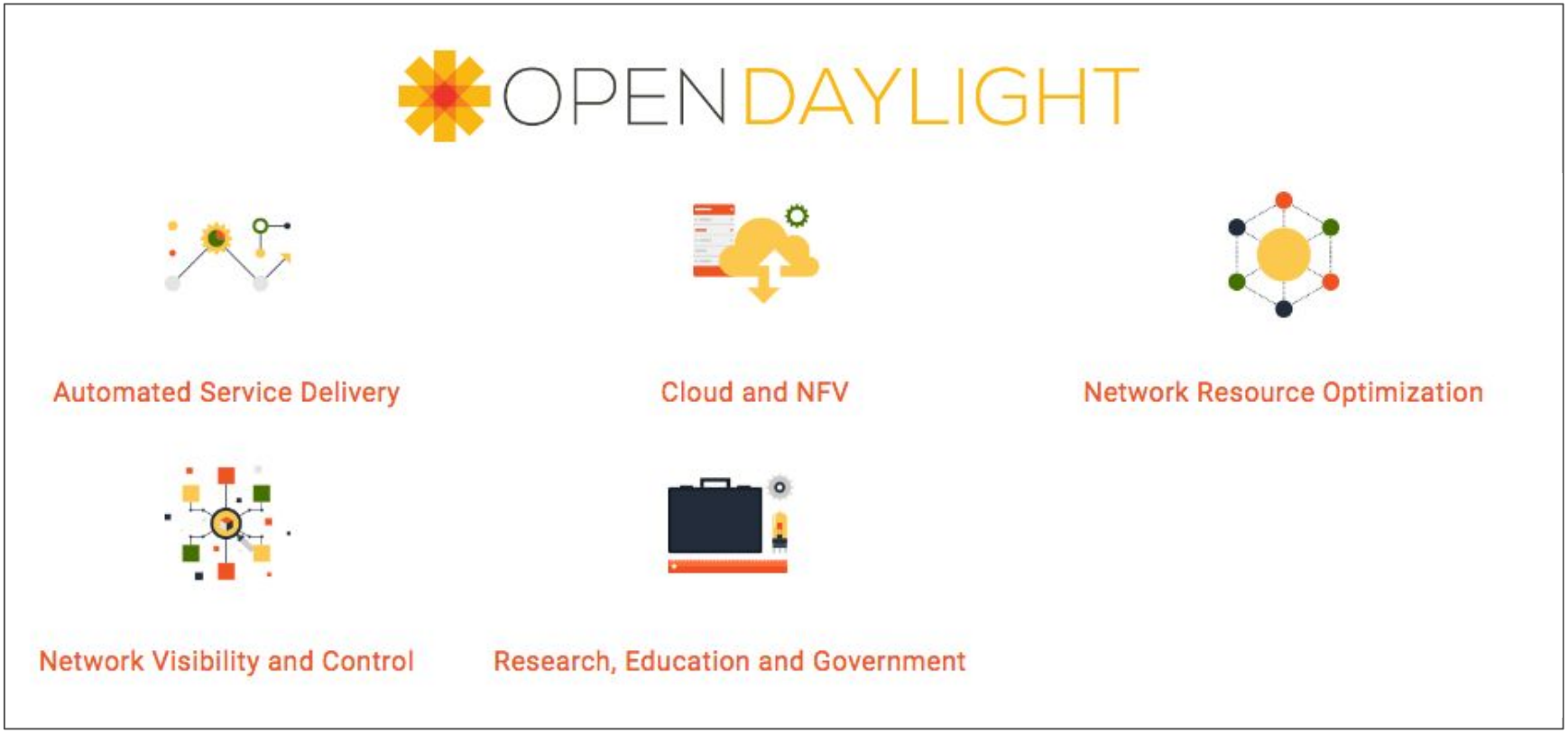
Software Defined Networking
¡Existen muchos casos de uso!



Visiten → https://www.opendaylight.org

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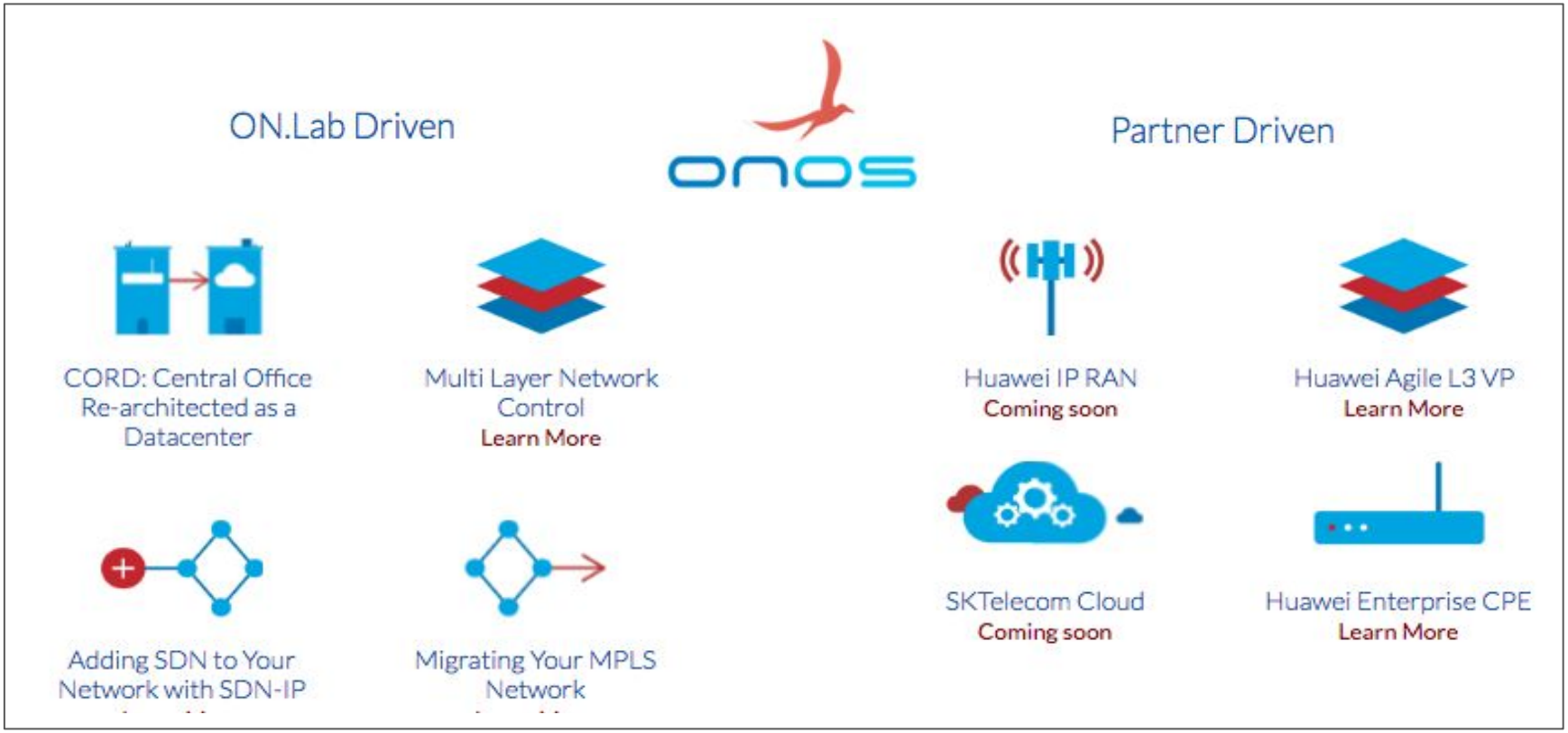
Software Defined Networking
¡Existen muchos casos de uso!



Visiten → http://onosproject.org/use-cases/

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Las 6 características de SDN

Separación de Planos
Forwarding simplificado
Control Centralizado
Automatización de Red
Virtualización
Apertura (“*Openness*”)

...y muchos casos exitosos!

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Agenda

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09:30 - 10:00	¿Por qué estamos aquí?
10:00 - 10:15	Movimiento Open Networking
10:15 - 11:00	Software Defined Networks
11:00 - 11:30	Receso
11:30 - 12:15	Network Function Virtualization
12:15 - 13:00	Programabilidad de Redes

Agenda

whitestack

09:30 - 10:00	¿Por qué estamos aquí?
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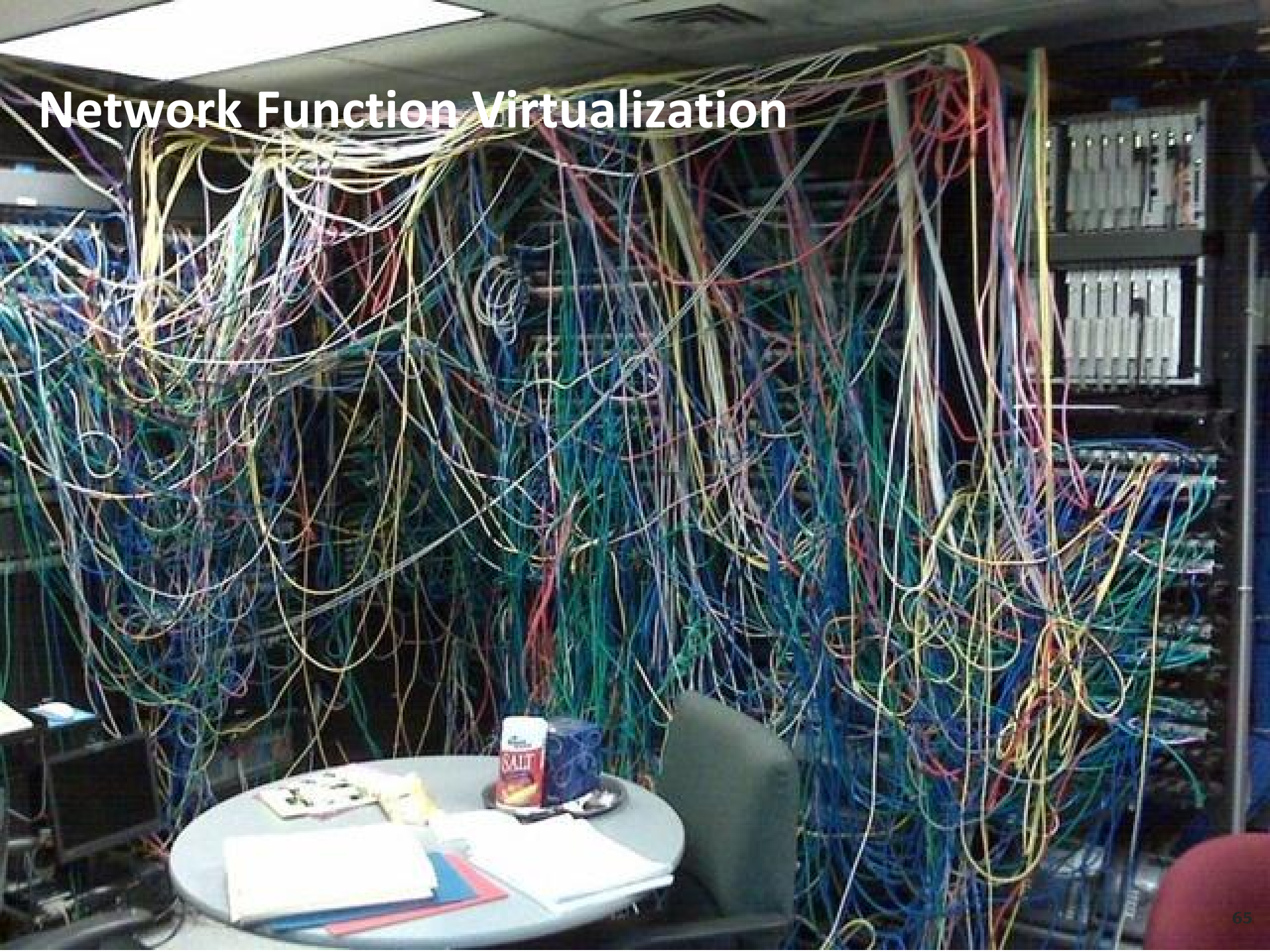
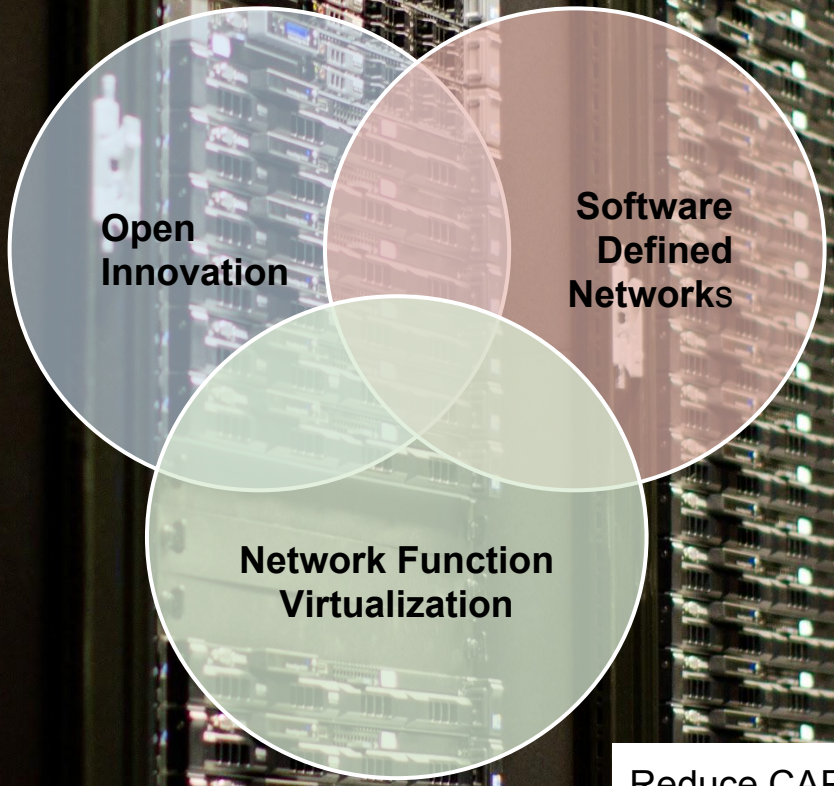
Network Function Virtualization



Network Function Virtualization

Crea oferta competitiva de aplicaciones innovadoras, desarrollada por terceros



Crea “Abstracciones de la Red”, que permite innovación más rápida

Reduce CAPEX, OPEX, y Consumo de Espacio y Energía.

Classical Network Appliance Approach

Message Router

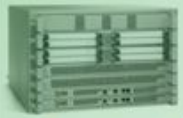
CDN

Session Border Controller

WAN Acceleration

DPI

Firewall


Carrier Grade NAT

Tester/QoE monitor

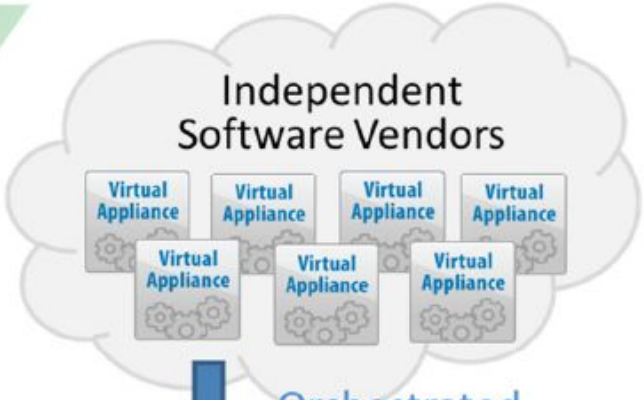
SGSN/GGSN

PE Router

BRAS

Radio Access Network Nodes

- Fragmented non-commodity hardware.
- Physical install per appliance per site.
- Hardware development large barrier to entry for new vendors, constraining innovation & competition.



Orchestrated, automatic & remote install.

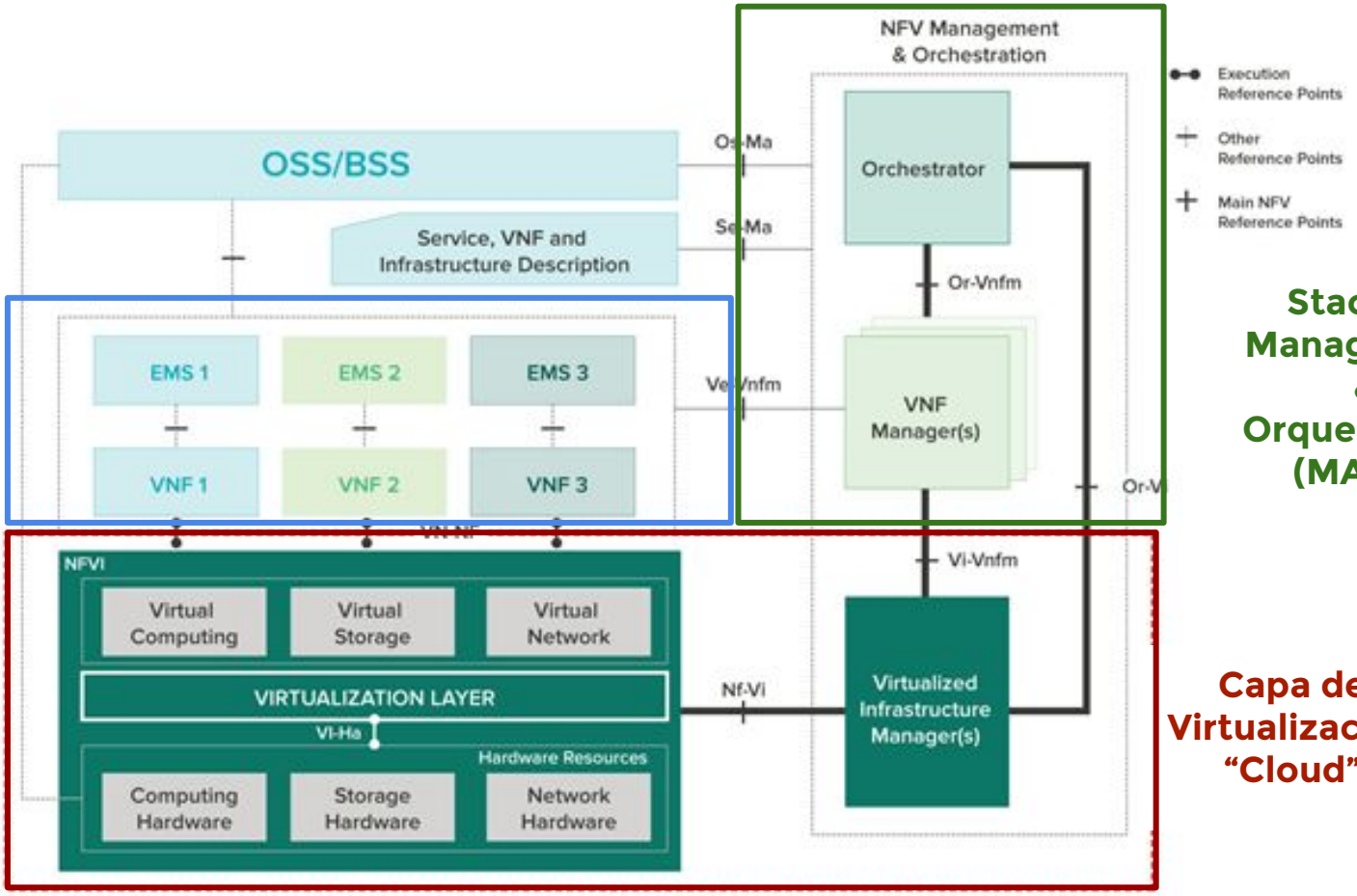
Standard High Volume Servers

Standard High Volume Storage

Standard High Volume Ethernet Switches

Network Virtualisation Approach

Modelo de Referencia ETSI

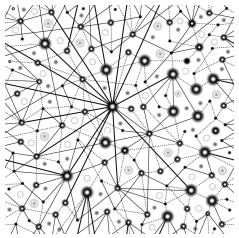


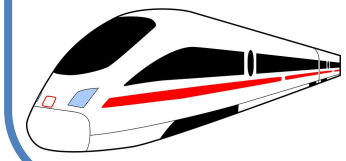
Funciones de Red *(Propietarias)*

Stack de Management & Orquestación (MANO)

Capa de Virtualización "Cloud"

¿Y Network Function Virtualization?





Cloud

+

SDN

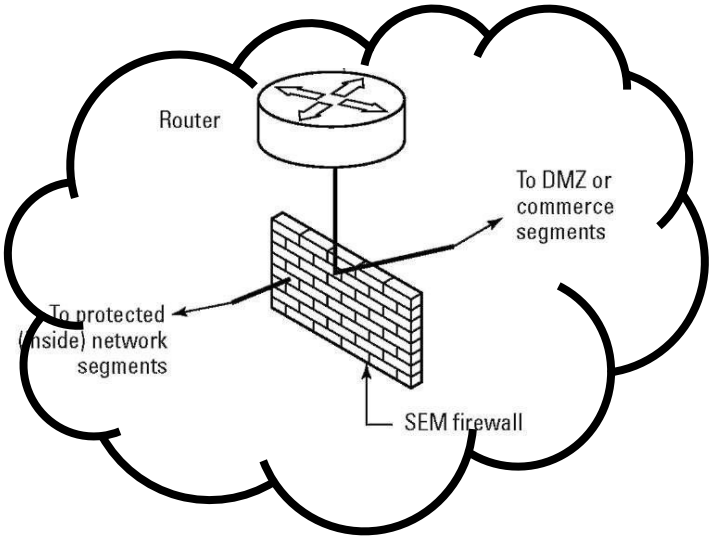
+

Orquestación

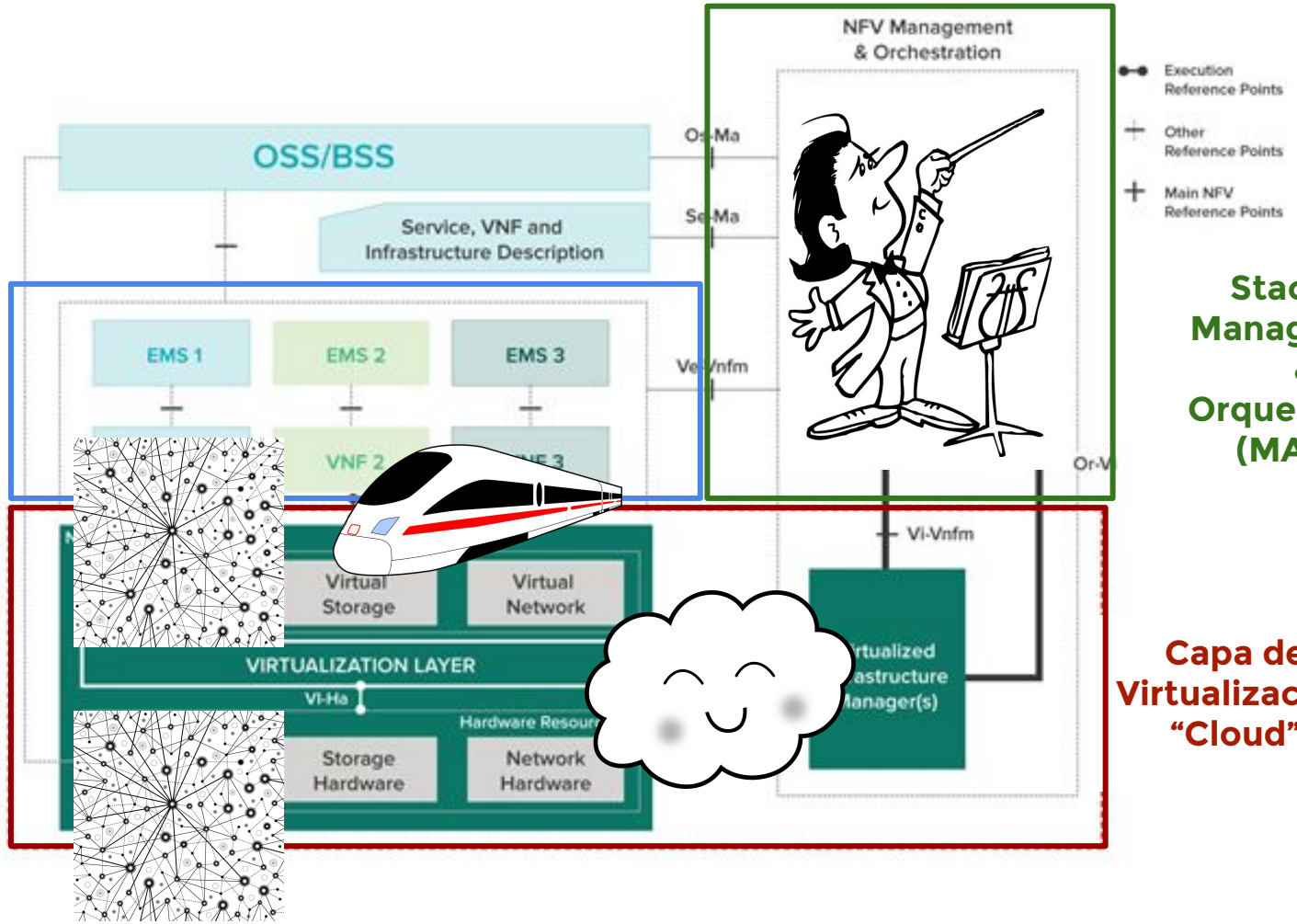
+

Performance

= NFV



Modelo de Referencia ETSI



Funciones de Red *(Propietarias)*

Stack de Management & Orquestación (MANO)

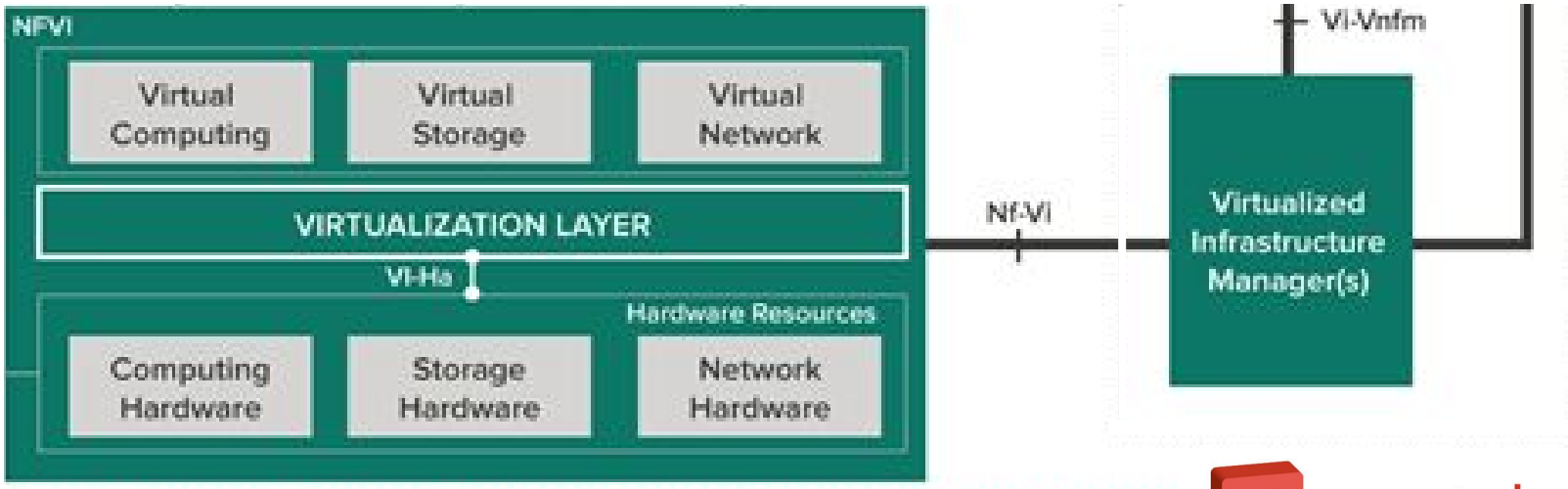
Capa de Virtualización "Cloud"

NFVI - NFV Virtualization Infrastructure
VIM - Virtual Infraestructure Manager

Se hace cargo de virtualizar máquinas

- Configurar VM (CPU, RAM, Disk, Red, Boot Image)
- Encender, Suspender y Apagar VM
- Configurar Storage
- Configurar Red

No le interesa la función de las VMs



Hardware: Servers x86
Sistema Operativo: Linux / Unix
Hypervisores: KVM, XEN (, vmware)

La industria ya adoptó Open Source!

Hewlett Packard Enterprise

Dec, 2015

NFV-SDN Opensource

MP Odini/HPE – ETSI NFV Vice Chair

OPENDAYLIGHT

Platinum: big switch networks, BROCADE, Microsoft, JUNIPER, IBM, CISCO, CITRIX, ERICSSON, redhat.

Gold: NEC, vmware

Silver: PLUMgrid, DELL, hp, FUJITSU, nuagenetworks, ARISTA, intel

CISCO

Open Source as Reference Implementation for Next Gen Network Services

Red Hat Summit and DevNation, June 27-30, 2016

Charles Eckel, Cisco DevNet

eckelcu@cisco.com

ONOS

Open Network Operating System

OPEN DAYLIGHT, Project Floodlight, OPENCONTRAIL, vmware, Alcatel-Lucent, nuagenetworks, CISCO, VAN SDN controller, nicira, BROCADE, VYATTA, APIC, PICA8 OVS, blueplanet

CISCO ERICSSON

OPNFV*: NFV system integration and development as an open community effort

Telecom operators are in the midst of modernizing their networks. They are leveraging the European Telecommunications Standards Institute (ETSI) Network Functions Virtualization (NFV) architectural framework to bring automation, agility, and flexibility to network infrastructure and services using proven IT virtualization and cloud technologies. NFV transformation requires newer, different capabilities than those available today in IT-based solutions. The Open Platform for Network Functions Virtualization (OPNFV) open-source project under the Linux Foundation is a carrier-grade, integrated open-source platform created to accelerate the introduction of new NFV products and services. This report describes OPNFV, its progress, and the joint efforts being made by Cisco, Ericsson, and other ICT industry players to bring the best-in-breed technologies and solutions to open source.

NFV and Openstack

Marie-Paule Odini – HP Communication Media Solution CT Office

ETSI NFV member: Steering Committee and Software Architecture co-chair

ATIS SDN-NFV member

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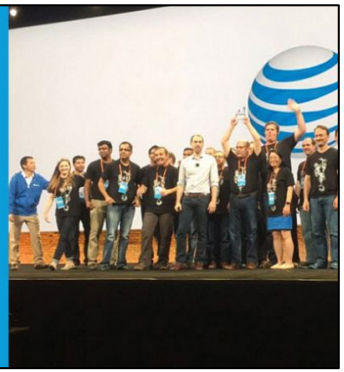
OpenStack Superuser

Recognizing CHANGE AGENTS in a SOFTWARE-DEFINED economy.

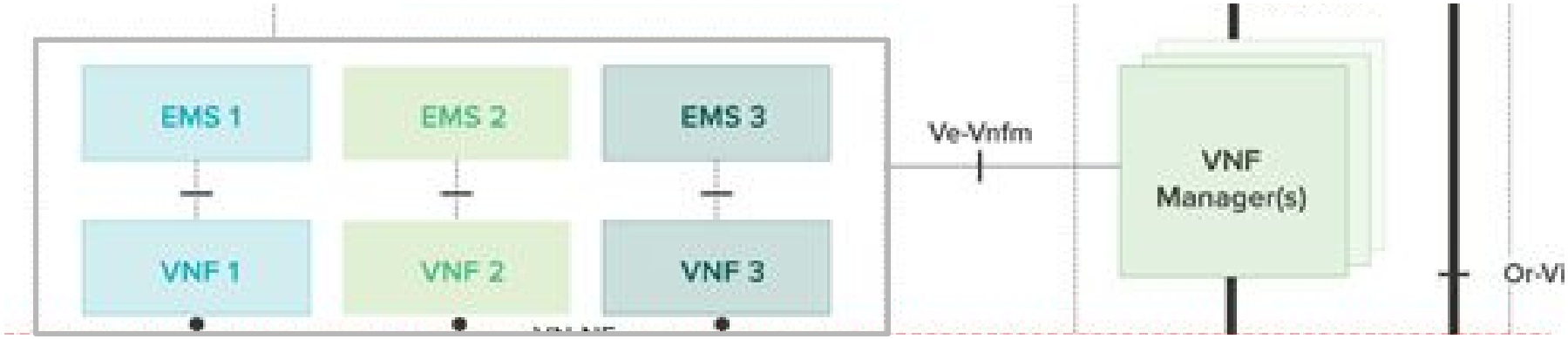
Credit: OpenStack Foundation



VNF - Virtual Network Functions

Son las funciones virtualizadas

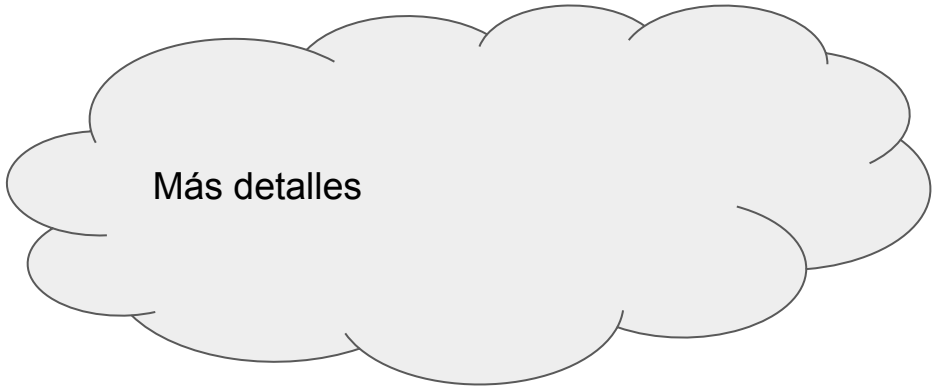
- **VNF**: Es la función virtualidad (ej, vRouter)
- **EMS**: Element Management System (maneja una o más VNF en forma propietaria) (ej, la configura, inicia, monitorea y detiene)
- **VNF Manager**: Administra el ciclo de vida de una VNF (Funciones de red) Podría usar los EMS (propietarios)

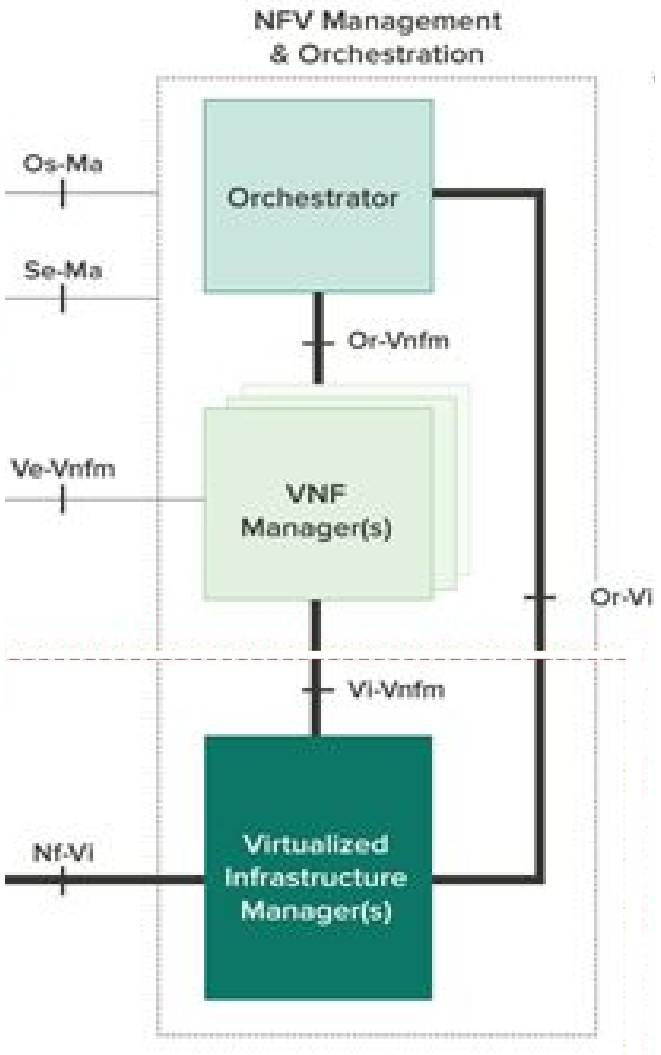


MANO - NFV Management AND Orchestration

Es la columna de gestión y orquestación

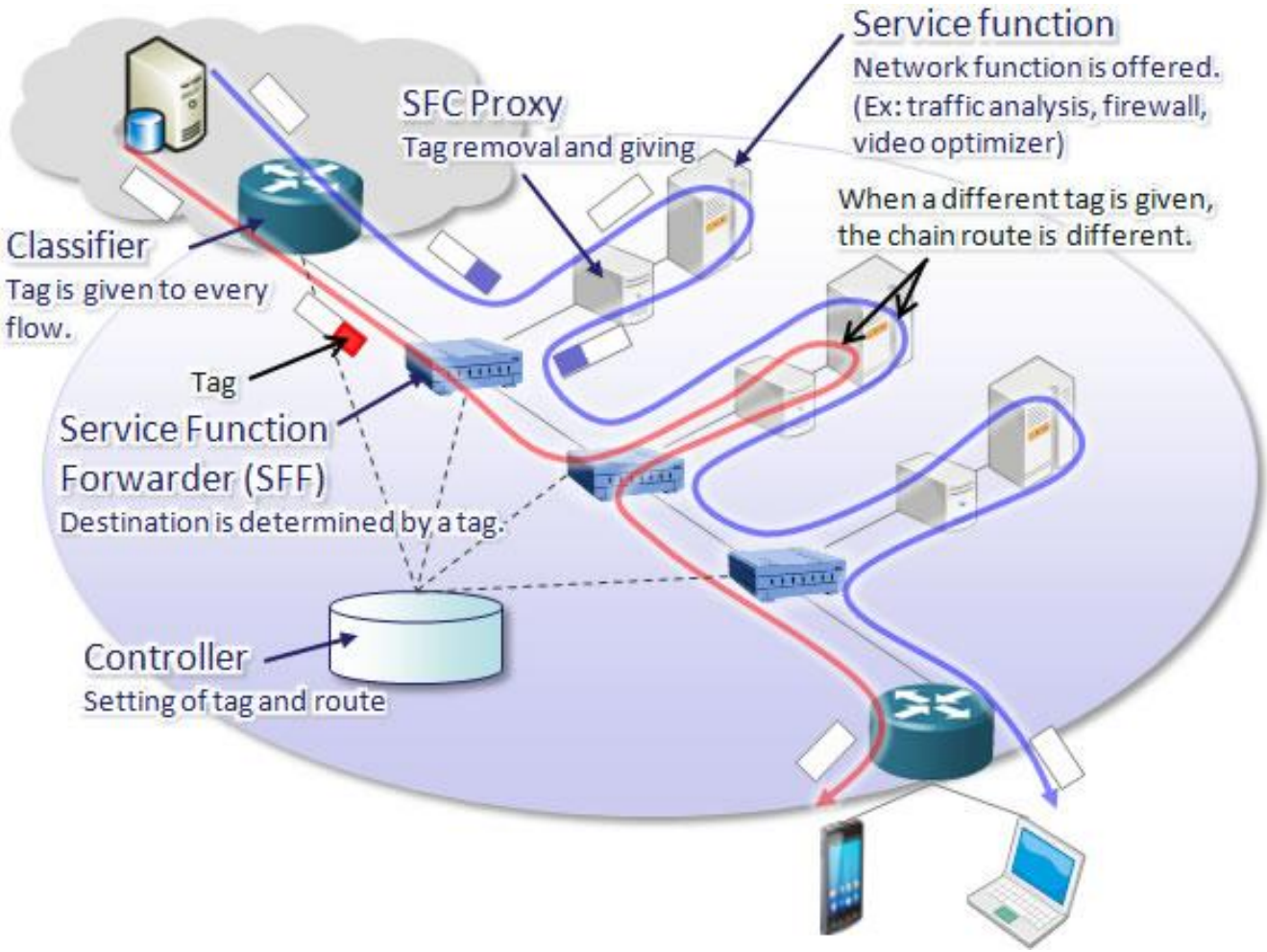
- **VIM**: Administra Virtual Machines
  (no sabe de función que desempeñan)
- **VNF Manager**: Administra el ciclo de vida de las Funciones de red
- **Orchestrator**: Administra Servicios de Red
  (Mediante concatenación de funciones de red)





SFC - Service Function Chaining

Construir servicios de red complejos, conectando las distintas VNFs, por software



Hardware “Hiper-escalable”

Soluciones “Enterprise”

Soluciones “Vanity-Free” Cloud

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The Open Compute Project

OPEN Compute Project

Open Compute v3

- Reuses the "v2" half-width motherboards
- Self-contained sled for Open Rack
- 3-across 2U form factor enables 80mm fans with 45 servers per rack

Facebook Open Vault Storage Server

Open Vault

- Storage JBOD for Open Rack
- Fills the volume of the rack without sacrificing hot-swap

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The Open Compute Project

Hiper-escalabilidad :)

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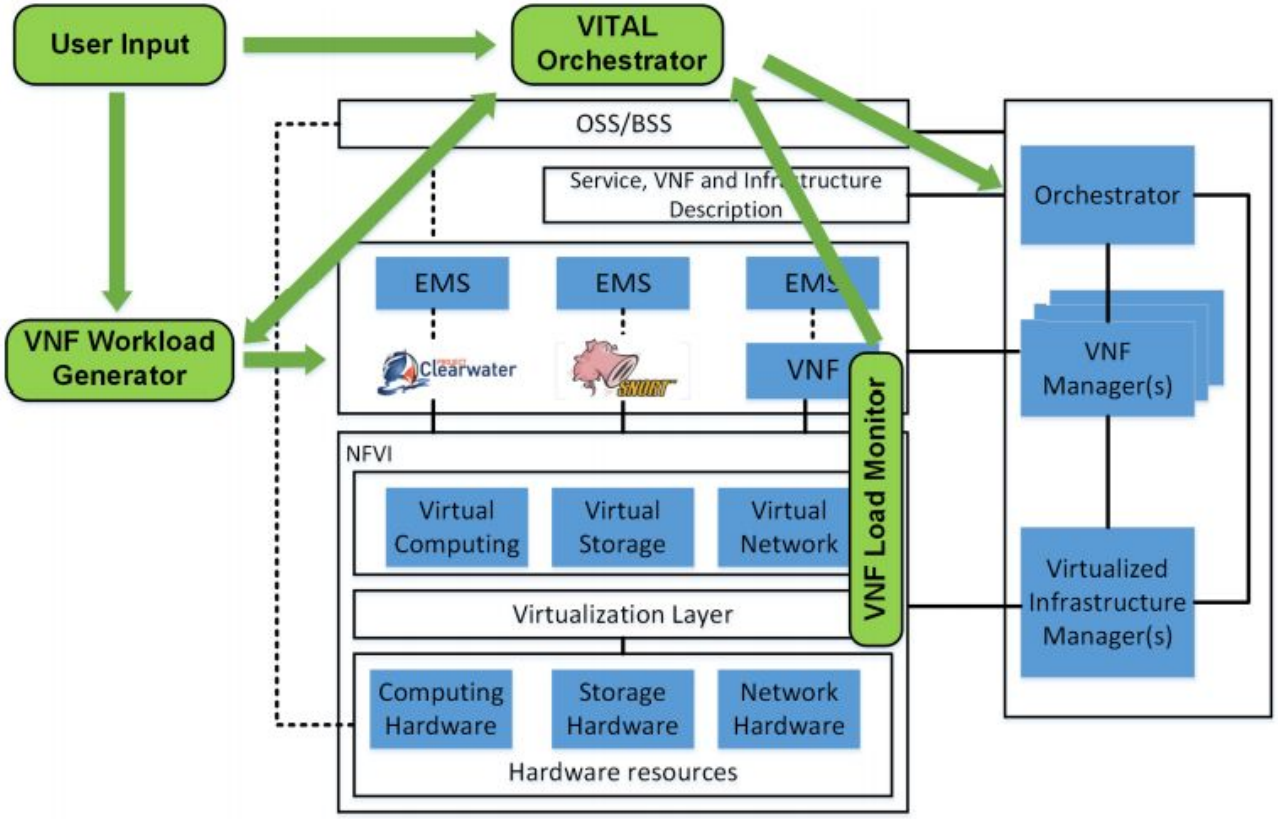
Medición Desempeño NFV

VITAL
VIrtualized hybrid satellite-Terrestrial systems for resilient And flexibLe future networks

NFV VITAL (Virtualization Impact on Throughput And Load)

Proyecto de HPE (China) Intel y China Unicom



Fuente: NFV-VITAL: A Framework for Characterizing the Performance of Virtual Network Functions

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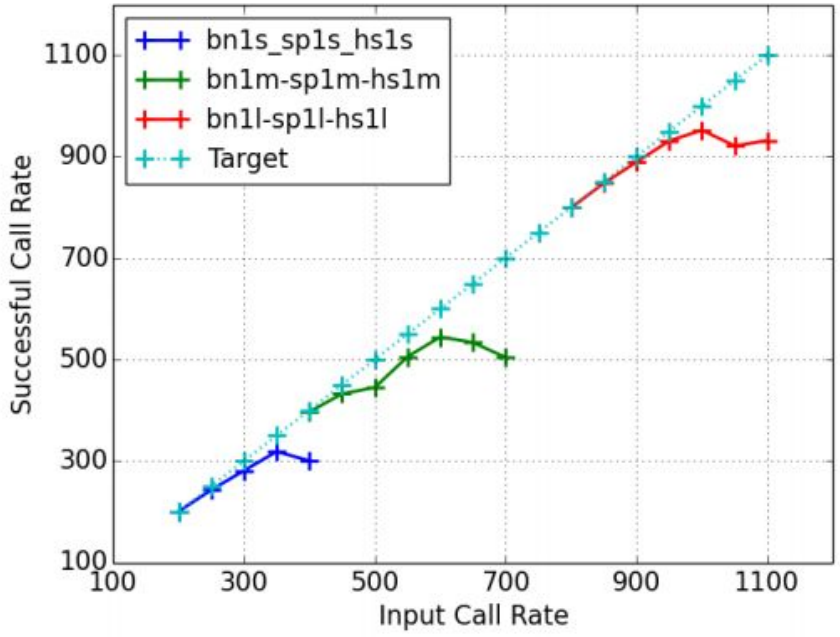
Medición Desempeño NFV

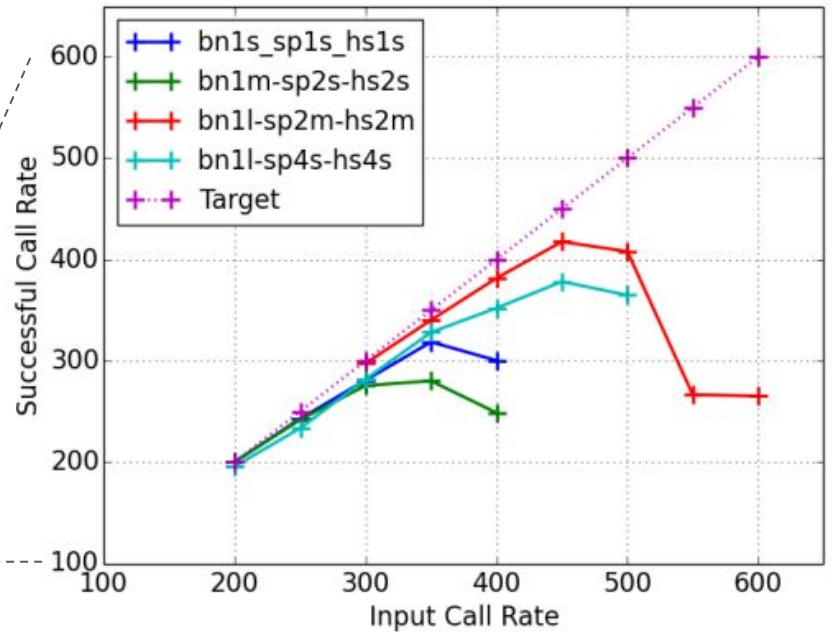
VITAL
VIrtualized hybrid satellite-Terrestrial systems for resilient And flexibLe future networks

NFV VITAL (Virtualization Impact on Throughput And Load)

Ejemplo, Rendimiento de un Virtual IMS



Scaling Up
(Más Potencia)



Scaling Out
(Más máquinas)

Fuente: NFV-VITAL: A Framework for Characterizing the Performance of Virtual Network Functions

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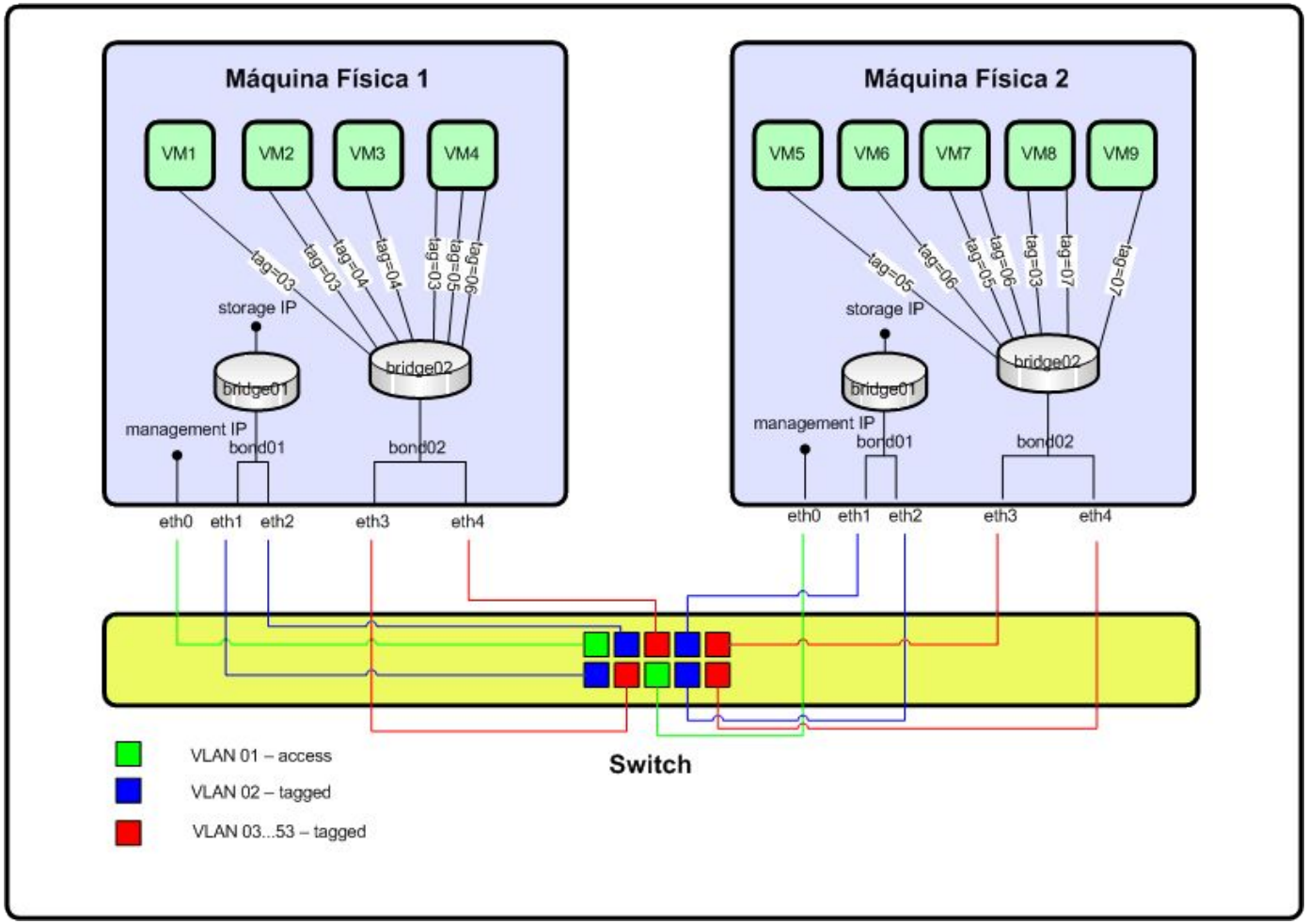
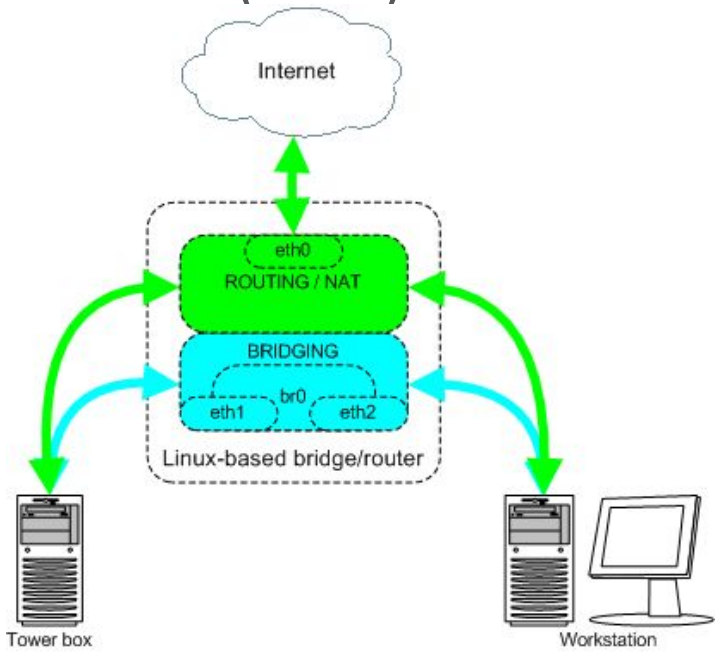
Dataplane - Los cables dentro del Cloud

El gran cuello de botella del Cloud, había sido la velocidad del forwarding de paquetes dentro del server.



Opción Dataplane: Linux Bridge

- Funcionalidad del Kernel de Linux, desde v2.4 (2000)
  - Rendimiento Moderado: ~ 1 Gbps



- Utiliza utilidad brctl

```
sriram@ubuntu-probook:~$ brctl showmacs myvirtbridge
port no mac addr                is local?       ageing timer
  2     52:54:00:81:ad:5a       no                 8.32
  3     52:54:00:f2:36:d8       no                 0.67
  1     80:1f:02:d6:09:39       no                66.96
  1     b4:b5:2f:78:29:fe       yes                0.00
  1     d0:e7:82:f3:6e:3c       no                67.82
  1     e8:de:27:3d:e4:11       no                 1.99
  2     fe:54:00:81:ad:5a       yes                0.00
  3     fe:54:00:f2:36:d8       yes                0.00
sriram@ubuntu-probook:~$
```

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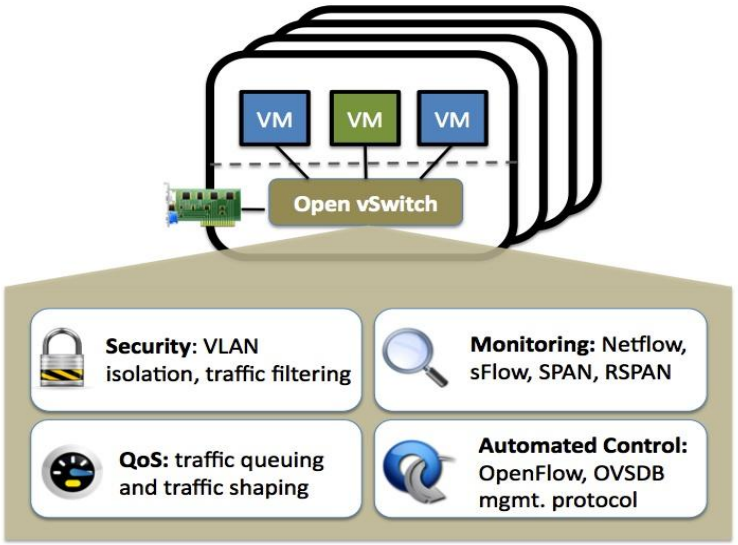
Opción Dataplane: Open vSwitch

- Proyecto Open Source

  (Linux Foundation)
  - Provee un switch de software con funcionalidades avanzadas (apto para producción)
  - Control: OpenFlow
  - Gestión: ovsdb ó of-config
  - Rendimiento: ~ 1.2 Gbps
- Se administra con utilidades propias de ovs
  - ovs-vsctl
  - ovs-ofctl




```
root@computenode1:~# ovs-vsctl show
8916031b-6b00-4bc5-a830-75277e45fb5d
    Bridge br-tun
        Port br-tun
            Interface br-tun
                type: internal
        Port "gre-1"
            Interface "gre-1"
                type: gre
                options: {in_key=flow, out_key=flow, remote_ip="10.10.10.1"}
        Port patch-int
            Interface patch-int
                type: patch
                options: {peer=patch-tun}
    Bridge br-int
        Port "qvo1e97237d-25"
            tag: 1
            Interface "qvo1e97237d-25"
        Port br-int
            Interface br-int
                type: internal
        Port "qvodaffdbd7-01"
            tag: 1
            Interface "qvodaffdbd7-01"
        Port patch-tun
            Interface patch-tun
                type: patch
                options: {peer=patch-int}
        Port "qvoc65f208c-61"
            tag: 4
            Interface "qvoc65f208c-61"
    ovs_version: "1.4.0+build0"
```

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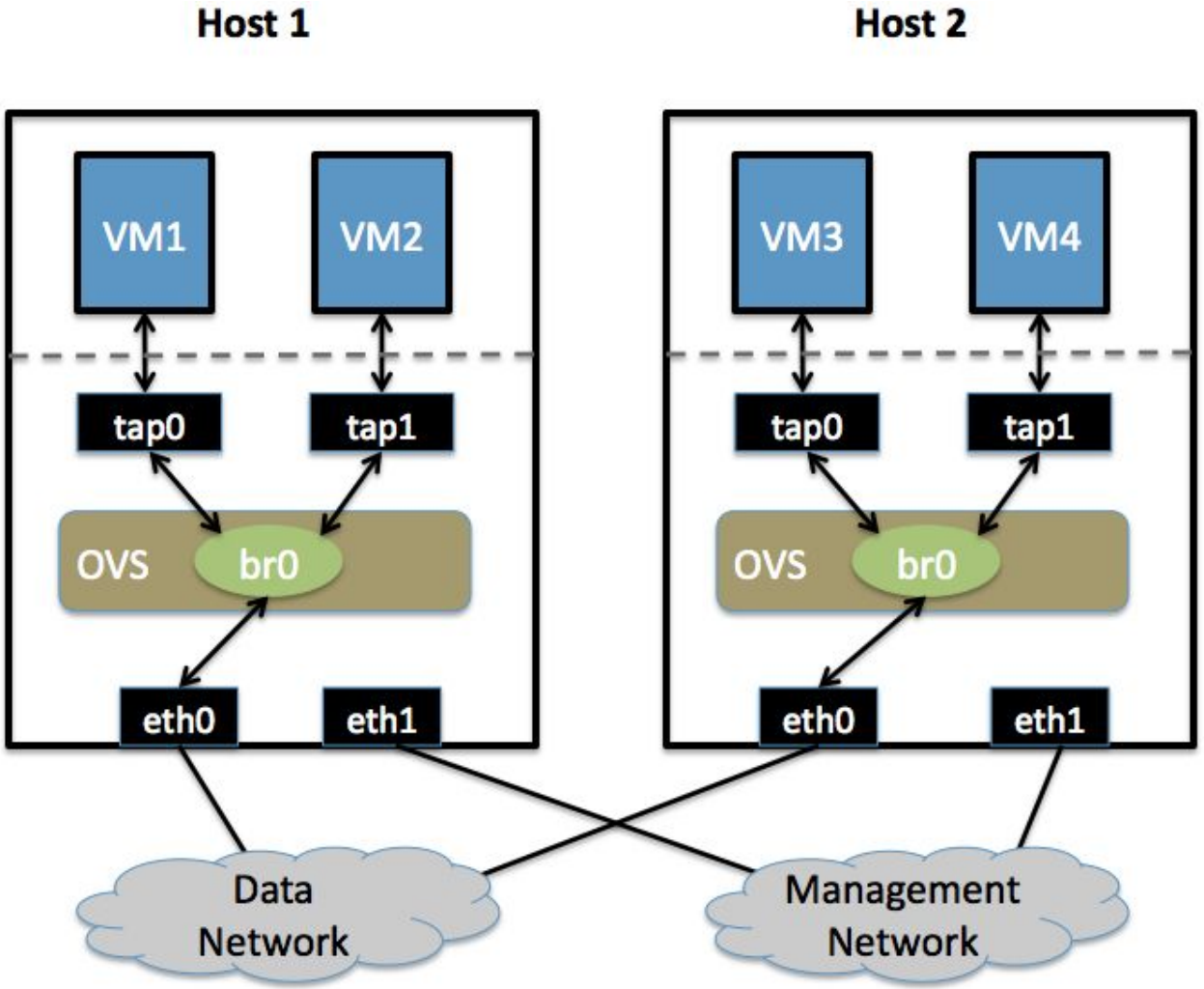
Opción Dataplane: Open vSwitch

Despliegue en Cloud (NFVI)



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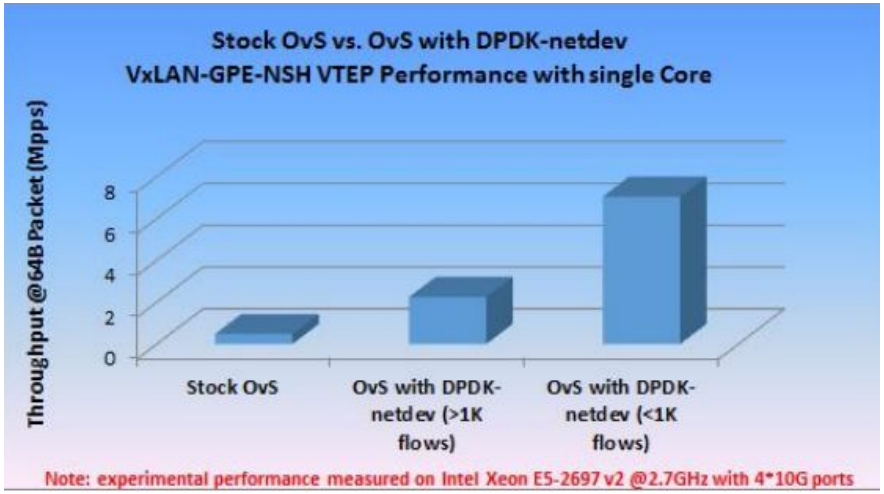
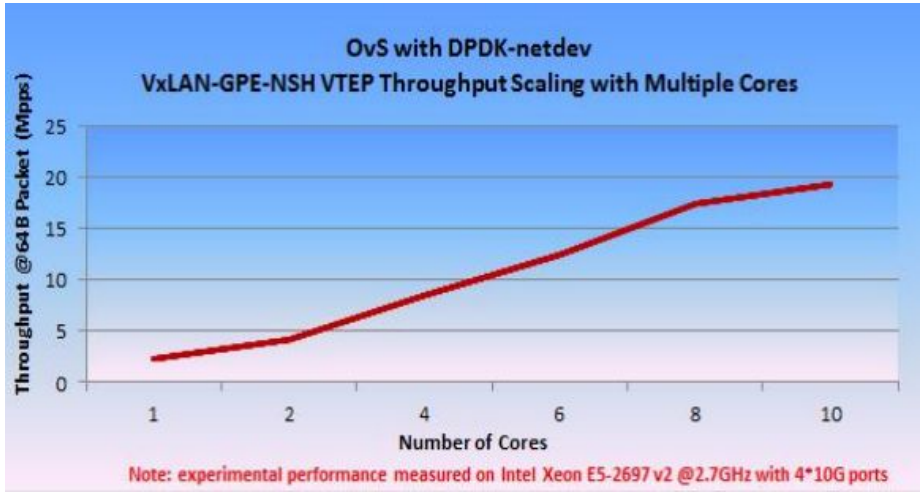
Opción Dataplane: Open vSwitch + DPDK

Intel Data Plane Development Kit

- Open-source (INTEL)
- By-passea el código de networking de linux, y ofrece una forma más eficiente de escalar
- Rendimiento > 10Gbps



Mejora OVS ~ x10



Escala casi lineal con número de cores

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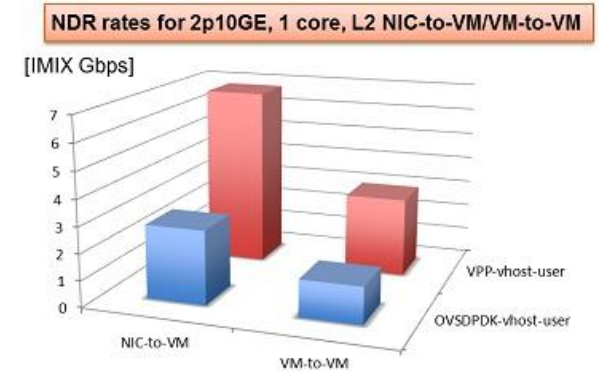
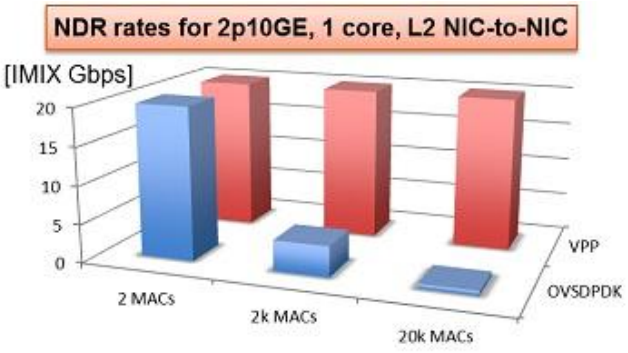
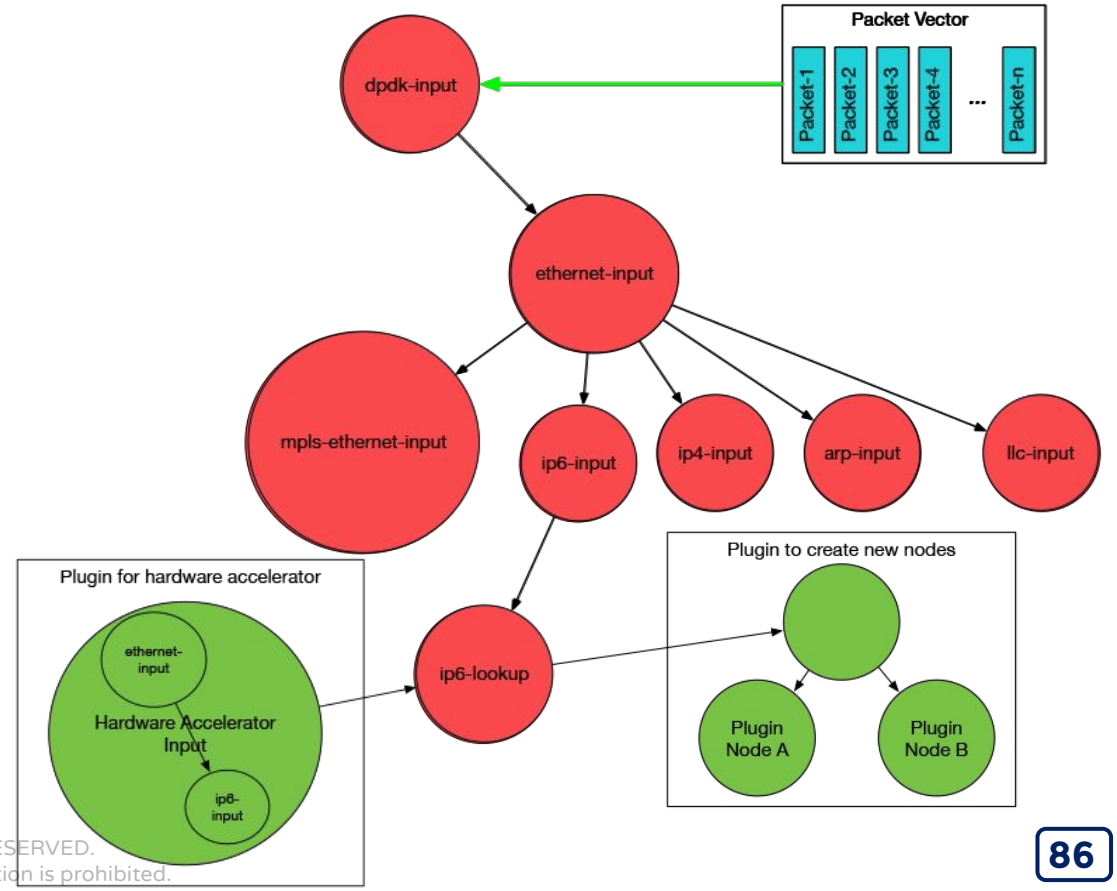
Opción Dataplane: FD.io (VPP)

- Proyecto Open-Source (Cisco)
  - Procesa “vectores de paquetes”
  - Vector Packet Processing (VPP) technology.
  - Altísimo rendimiento y Muy estable (jitter bajo)
  - Plugins: Aceleración







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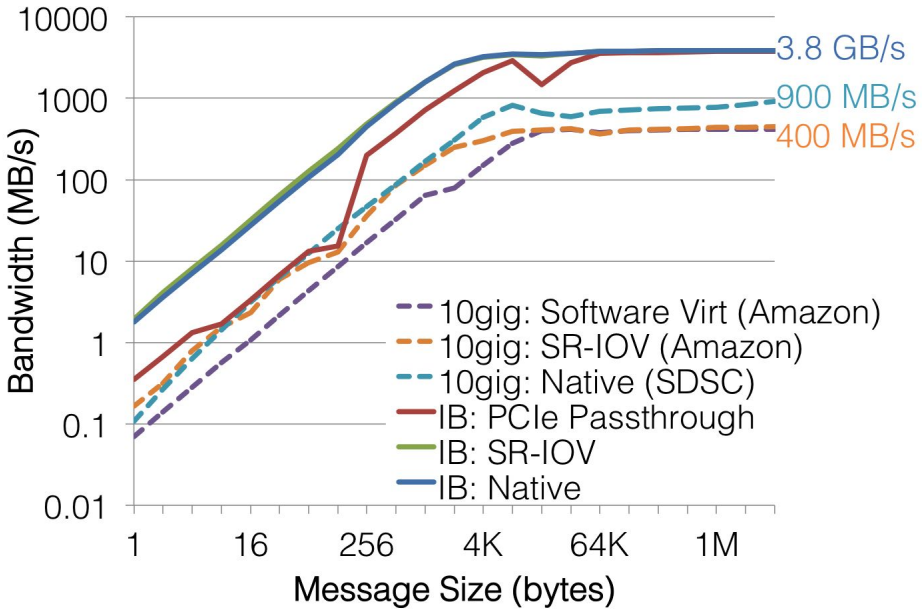
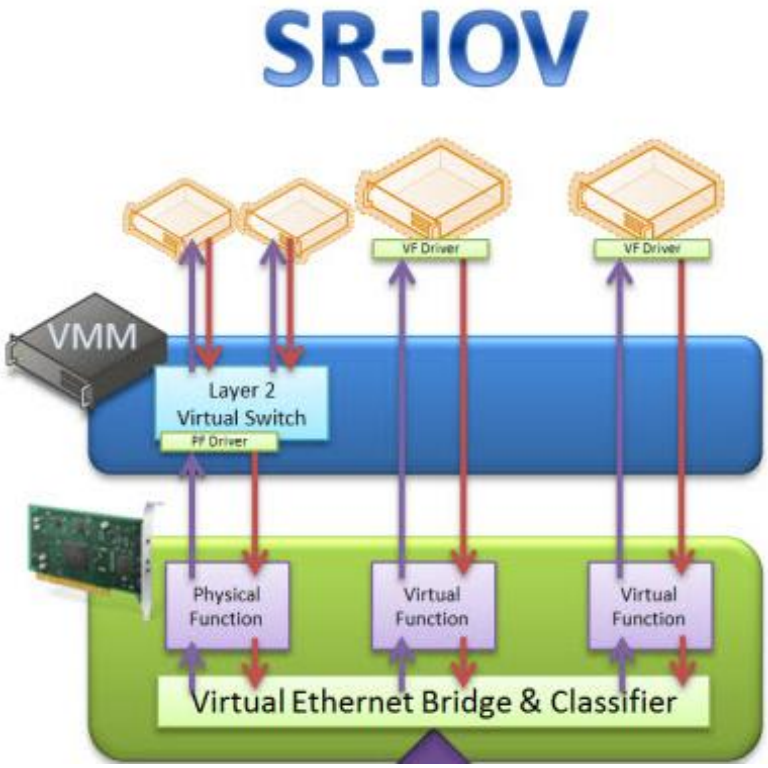
Opción Dataplane: SR-IOV
(Single Root I/O Virtualization)

- Técnica para hacer más eficiente el uso de NICs PCIe
  - La tarjeta de red expone
    - physical functions (PFs): La tarjeta propiamente tal
    - virtual functions (VFs): Una tarjeta virtual (más basiva) (máx: 256 VF por cada PF)
  - Debe ser soportado por la BIOS
  - Rendimiento ~ 4Gbps





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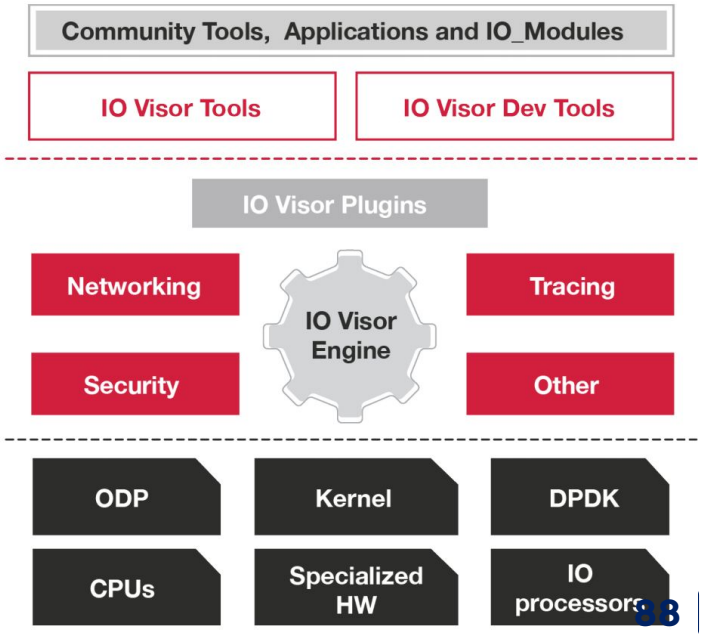
Opción Dataplane: IO Visor

Dataplane programable en Linux

- Permitir implementar nuevas funciones en el dataplane, de modo de alcanzar los requerimientos de Cloud, SDN,NFV e IOT
- Proyecto Open-Source (Cisco, Huawei, Broadcom, et al)
- Busca programar aplicaciones que son interpretadas en una VM en el Kernel

- IO Visor Engine: Es un intérprete de Instrucciones de networking (hardware o software)
- IO Visor Plugins: programas que implementan funcionalidad y que son interpretados por la VM



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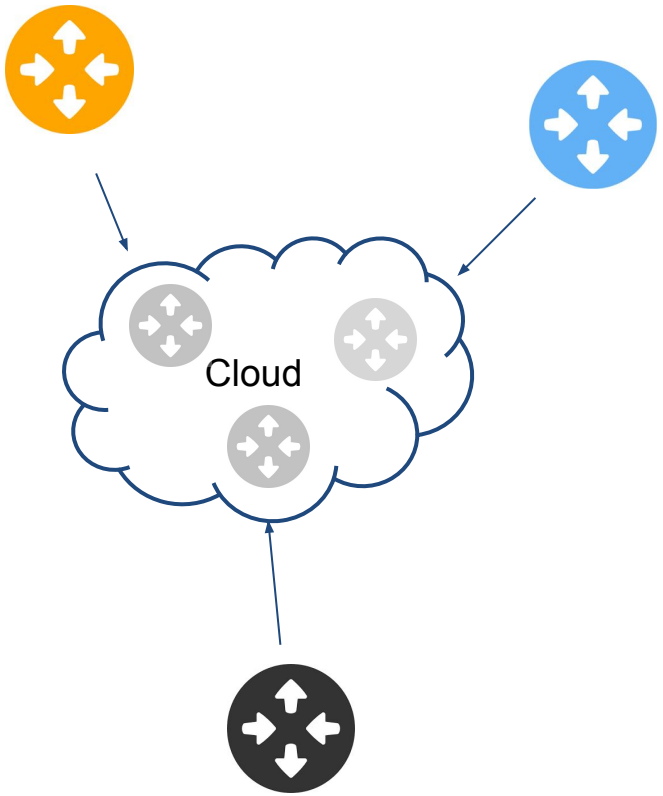
NFV: Agregar o desagregar funciones de red?

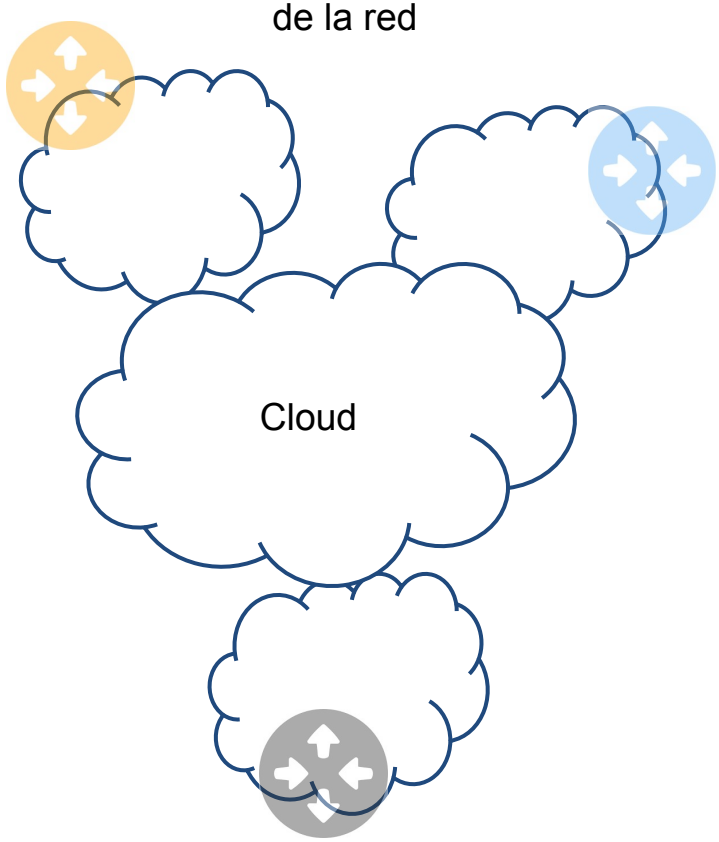
Agregar

Concentrar funciones de borde de la red, en una nube central



Desagregar

Extender la nube hasta los bordes de la red



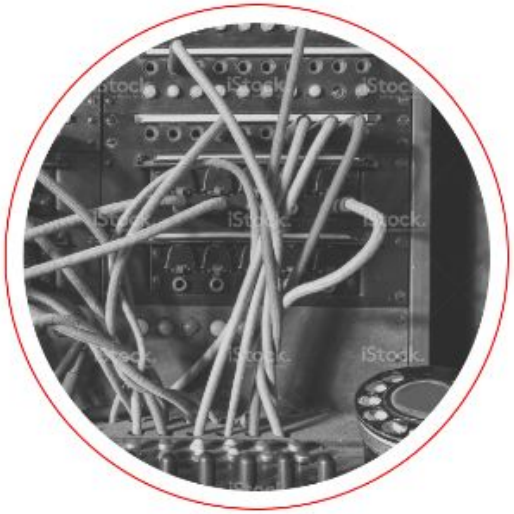
NFV: Agregar o desagregar funciones de red?

Funciones Agregadas

- CloudVPN
- vEPC
- vCPE

Funciones Desagregadas

- vDSLAM
- vBRAS
- vCMTS



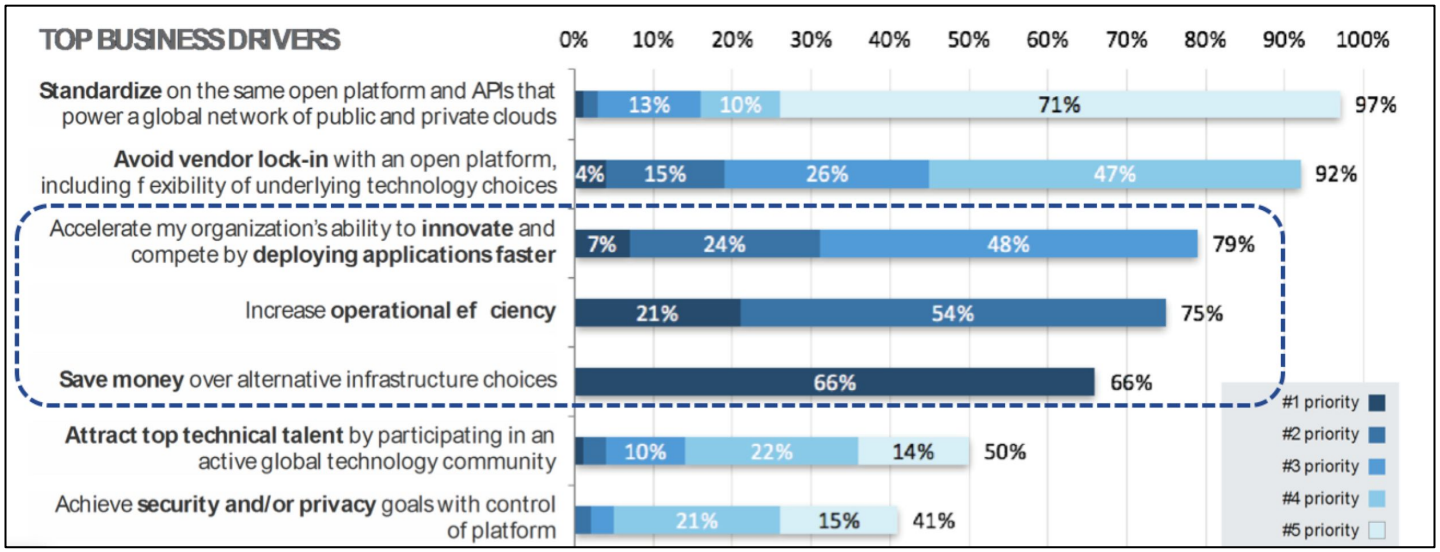
Past

Future

CORD
Central Office Reachitected as Datacenter

Los 3 principales Drivers de Negocio para CORD

- Acelerar Innovación (desplegar aplicaciones más rápido)
- Aumentar Eficiencia Operacional
- Reducir Costos (CAPEX/OPEX) frente a otros modelos



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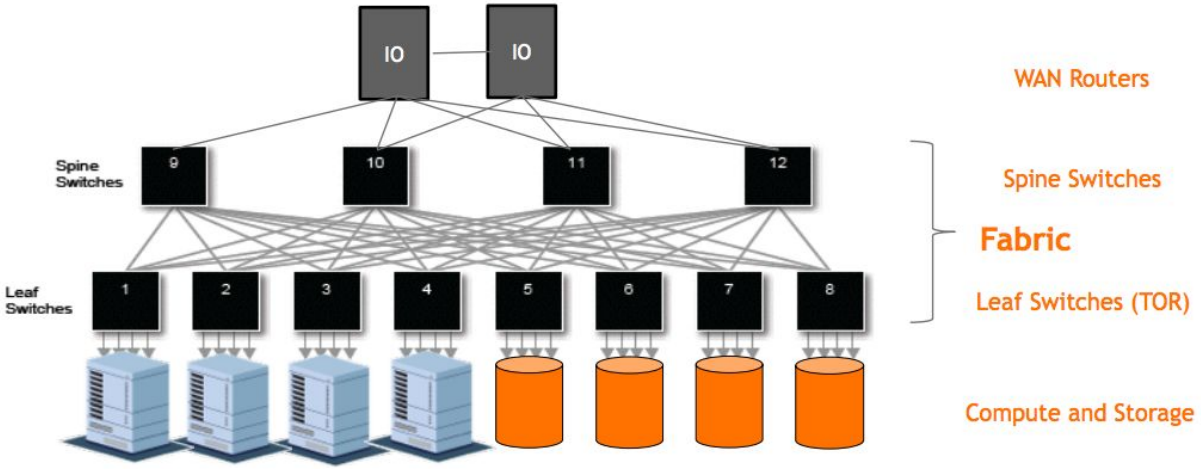
CORD
Central Office Reachitected as Datacenter

Arquitectura

- Hardware Commodity (x86)
- Whitebox Switches (10/40Ge)
  - Topología de CLOS (Spine/Leaf)
- Software Open Source
  - Linux, Openstack, ONOS, Docker
- Red Metro (eg, GPON)
- POD: Unidades “Rackeables”



Source: “An Introduction to CORD and its Application to Wireline Access”, Tom Anschutz, Architecture & Planning, AT&T

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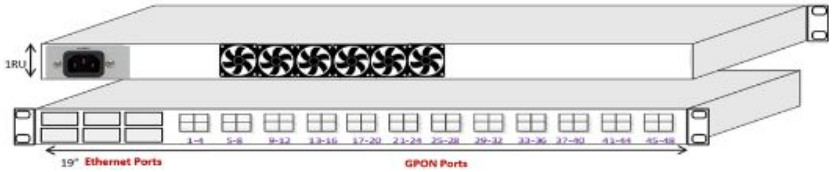
CORD
Central Office Reachitected as Datacenter

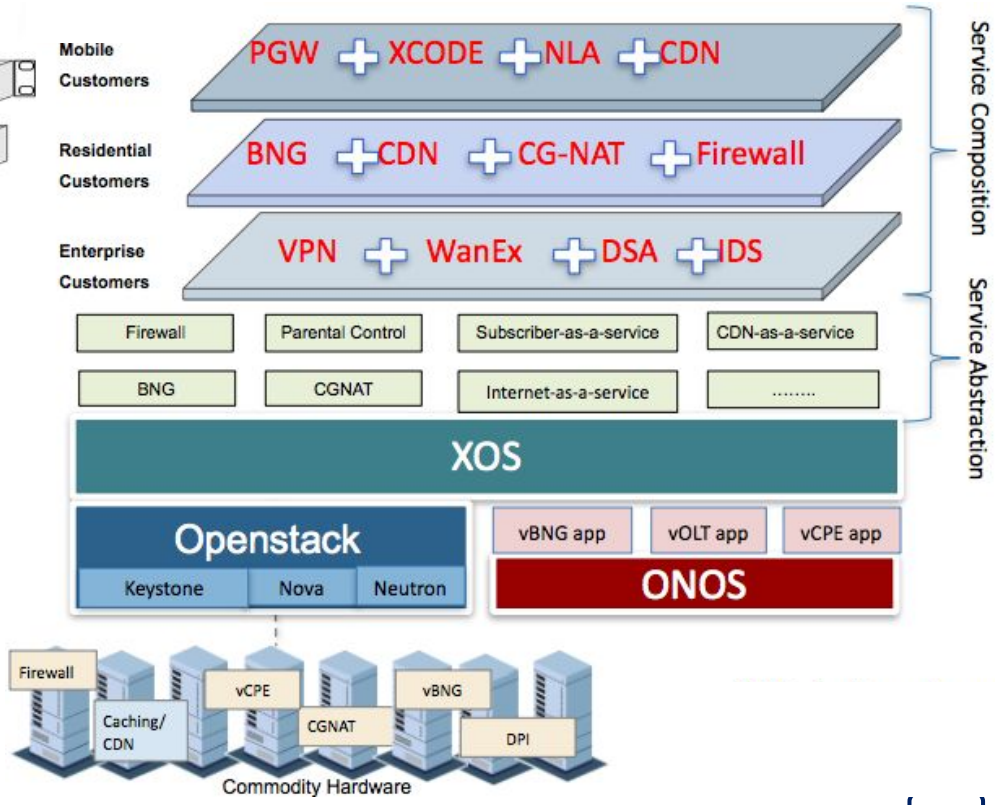
Casos de Uso

- M-CORD: Servicios Moviles
  - Parte de vEPC (Virtual Evolved Packet Core)
  - Incl: vENode-B (virtual eNode-B + Radio I/O) NEW
- R-CORD: Servicios Residenciales
  - Incl: vOLT (Virtual OLT) - SDN



vOLT - Pizza Box

- E-CORD: Servicios Empresas
  - Incl: vOLT, SD-WAN, vCE
- A-CORD: Analytics



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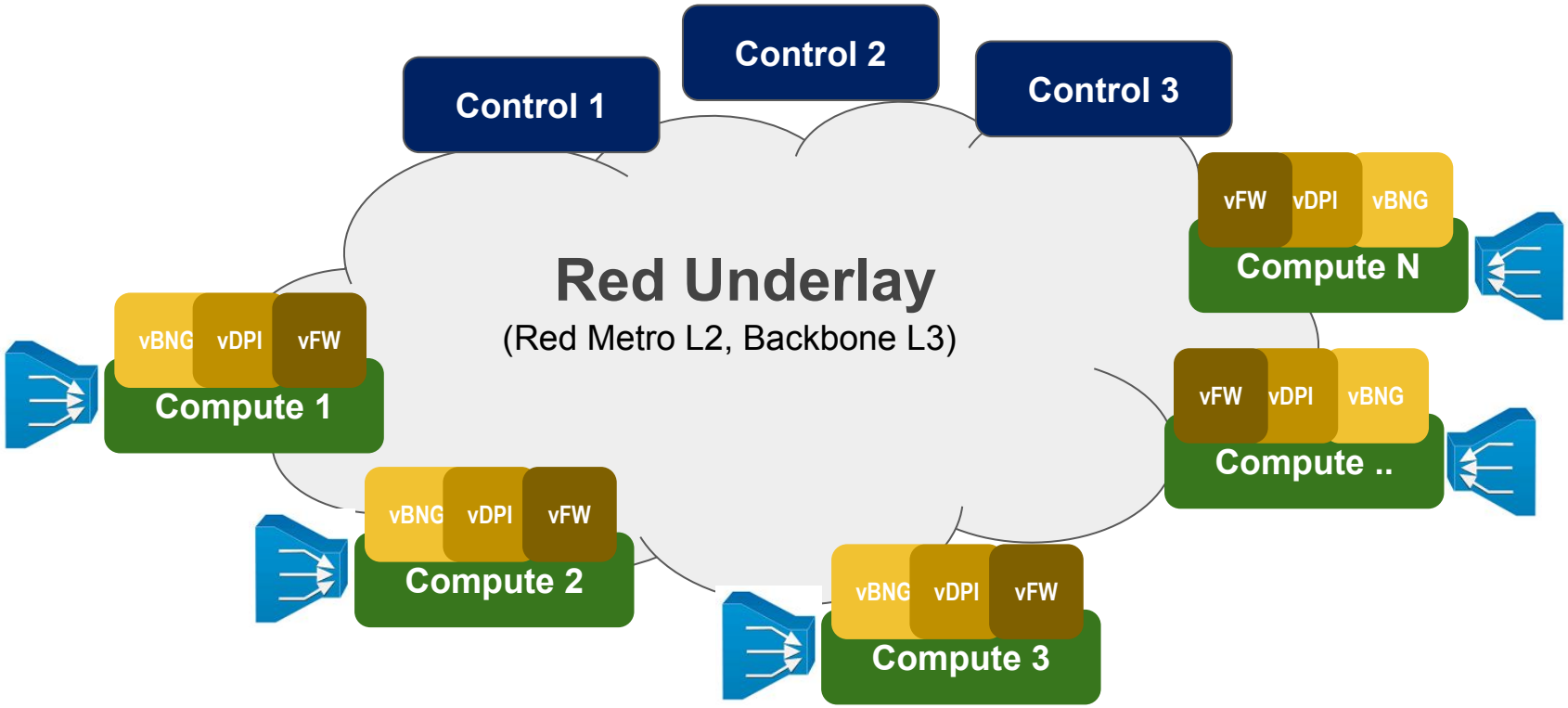
CORD-Light

Los mismos objetivos de CORD, sin el “compliance” requerido

Distribuir las funciones de red, tan cerca del acceso como posible!

- Usar capacidades de virtualización (nova) para instalarlas junto (o muy cerca) del concentrador de acceso



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Resumen: Network Function Virtualization

- Cloud + SDN + Orquestación + Performance
- Modelo de referencia ETSI (NFVI + MANO)
- Hardware Hiperescalable (OCP)
- Muy importante mantener alto desempeño
- Optimización de Dataplanes (varias opciones)
- Agregar y Desagregar
- CORD (lite)

Agenda

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09:30 - 10:00	¿Por qué estamos aquí?
10:00 - 10:15	Movimiento Open Networking
10:15 - 11:00	Software Defined Networks
11:00 - 11:30	Receso
11:30 - 12:15	Network Function Virtualization
12:15 - 13:00	Programabilidad de Redes

¿Nueva Red, Nuevos Ingenieros de Red?

by
Chuck Moozakis
Executive Editor

Network engineering jobs have moved from crimping cable to managing traffic between VMs. Software-everything means another seismic shift. Is the network engineer still relevant?

LinkedIn

88,617 **Python** jobs in **United States**

784 **SDN** jobs in **United States**

2,363 **Openstack** jobs in **United States**

1,550 **CCIE** jobs in **United States**

208 **YANG** jobs in **United States**

Network Programmability?

“Yo puedo hacer un script en perl que haga Telnet”

RFC 3535

Some command line interfaces lack a common data model. It is very well possible that the same command on different devices, even from the same vendor, behaves differently.

The command line interface is primarily targeted to humans which can adapt to minor syntax and format changes easily. Using command line interfaces as a programmatic interface is troublesome because of parsing complexities.

Command line interfaces often lack proper version control for the syntax and the semantics. It is therefore time consuming and error prone to maintain programs or scripts that interface with different versions of a command line interface.

Since command line interfaces are proprietary, they can not be used efficiently to automate processes in an environment with a heterogenous set of devices.

Network Programmability?

“Interface Prográmatica?: SNMP!”

RFC 3535

- There are scaling problems with regard to the number of objects in a device. While SNMP provides reasonable performance for the retrieval of a small amount of data from many devices, it becomes rather slow when retrieving large amounts of data (such as routing tables) from a few devices.

- There is too little deployment of writable MIB modules. While there are some notable exceptions in areas, such as cable modems where writable MIB modules are essential, it appears that router equipment is usually not fully configurable via SNMP.

- SNMP does not support easy retrieval and playback of configurations. One part of the problem is that it is not easy to identify configuration objects. Another part of the problem is that the naming system is very specific and physical device reconfigurations can thus break the capability to play back a previous configuration.

- There is often a semantic mismatch between the task-oriented view of the world usually preferred by operators and the data-centric view of the world provided by SNMP. Mapping from a task-oriented view to the data-centric view often requires some non-trivial code on the management application side.

Network Programmability!!

“Definición”

Desarrollo de aplicaciones interactúan con una red sobre **interfaces programables**

API

noun COMPUTING

a set of functions and procedures that allow the creation of applications which access the features or data of an operating system, application, or other service.

Qué se necesita?

Desarrollar Aplicaciones!!

Pero también…evolución de las redes: Desarrollo/Adopción de APIs, modelos de datos y nuevas tecnologías para exponer/controlar información de estado

Shortcut: SDN ? SDN Solo en el plano de management?

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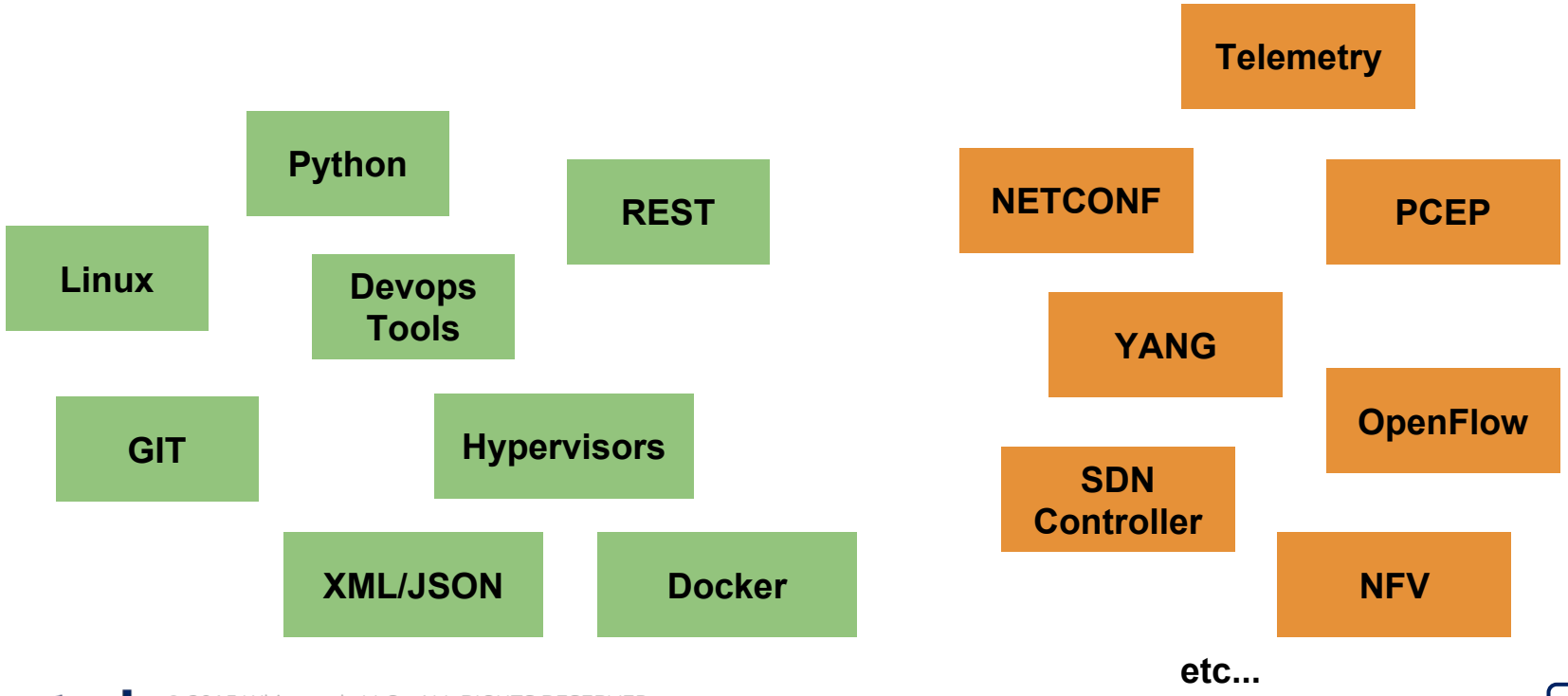
Network Programmability?

Tecnologías asociadas

Mix: Adopción de Tecnologías del Mundo TI + Desarrollo de Tecnologías de Red



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Network Programmability?

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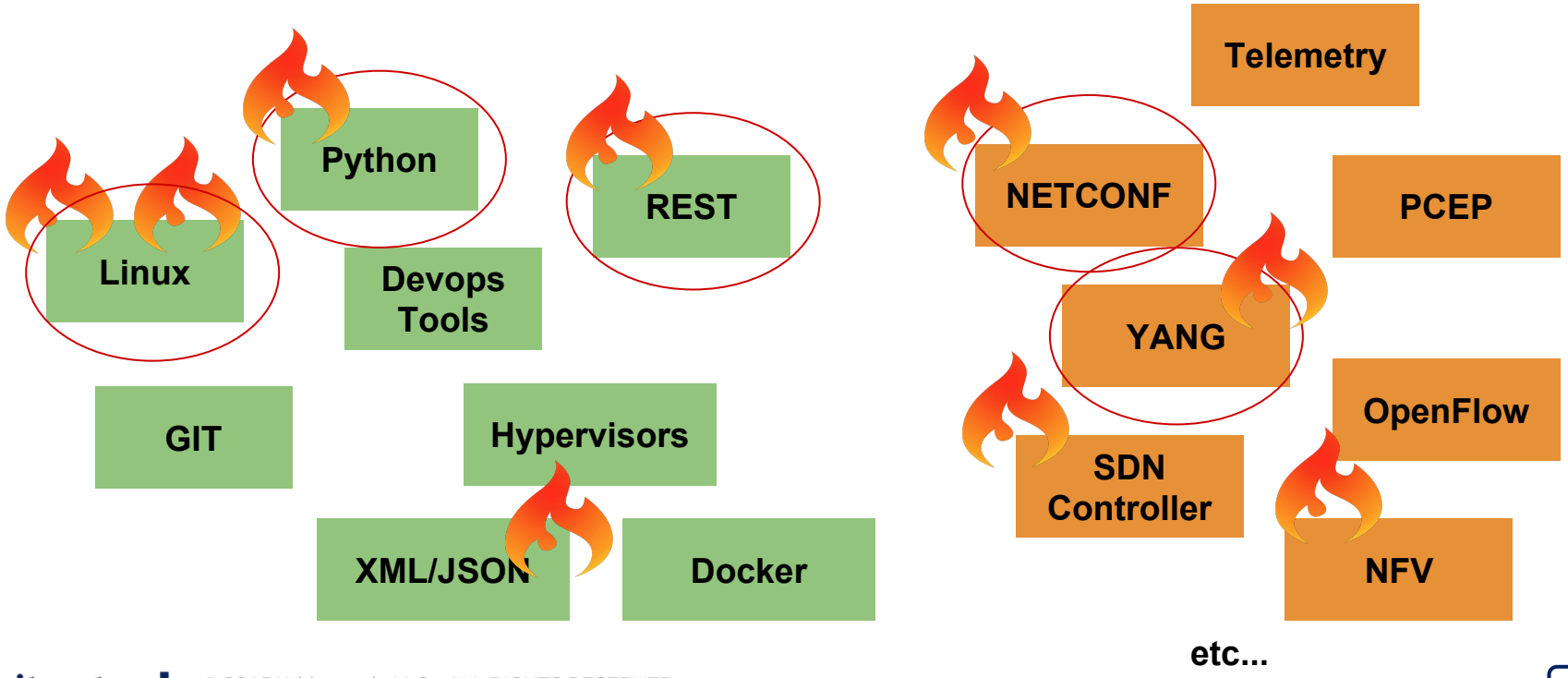

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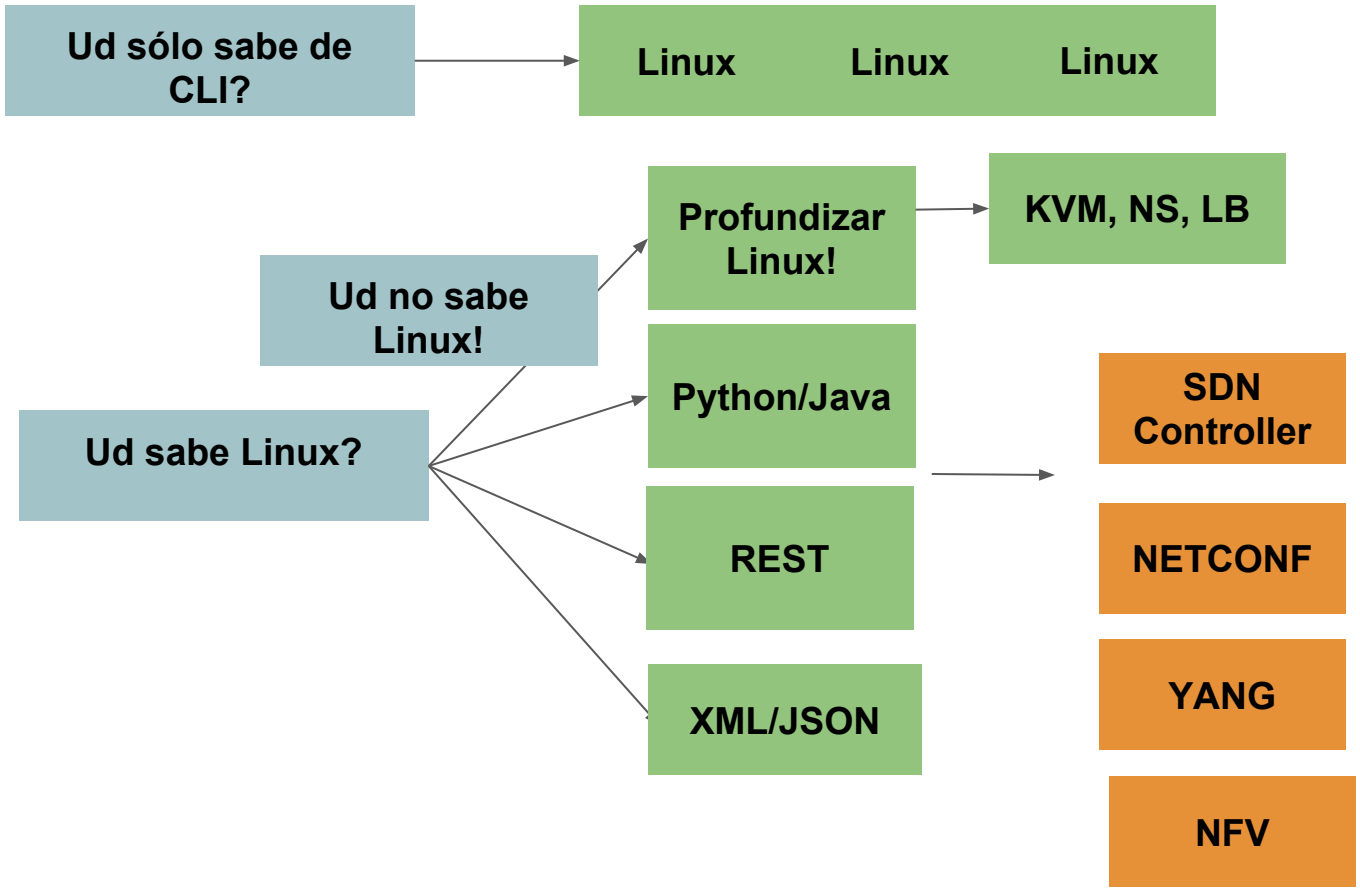
Roadmap de Aprendizaje, Por dónde empezar?

Depende del baseline...y hasta dónde quiere ud llegar...



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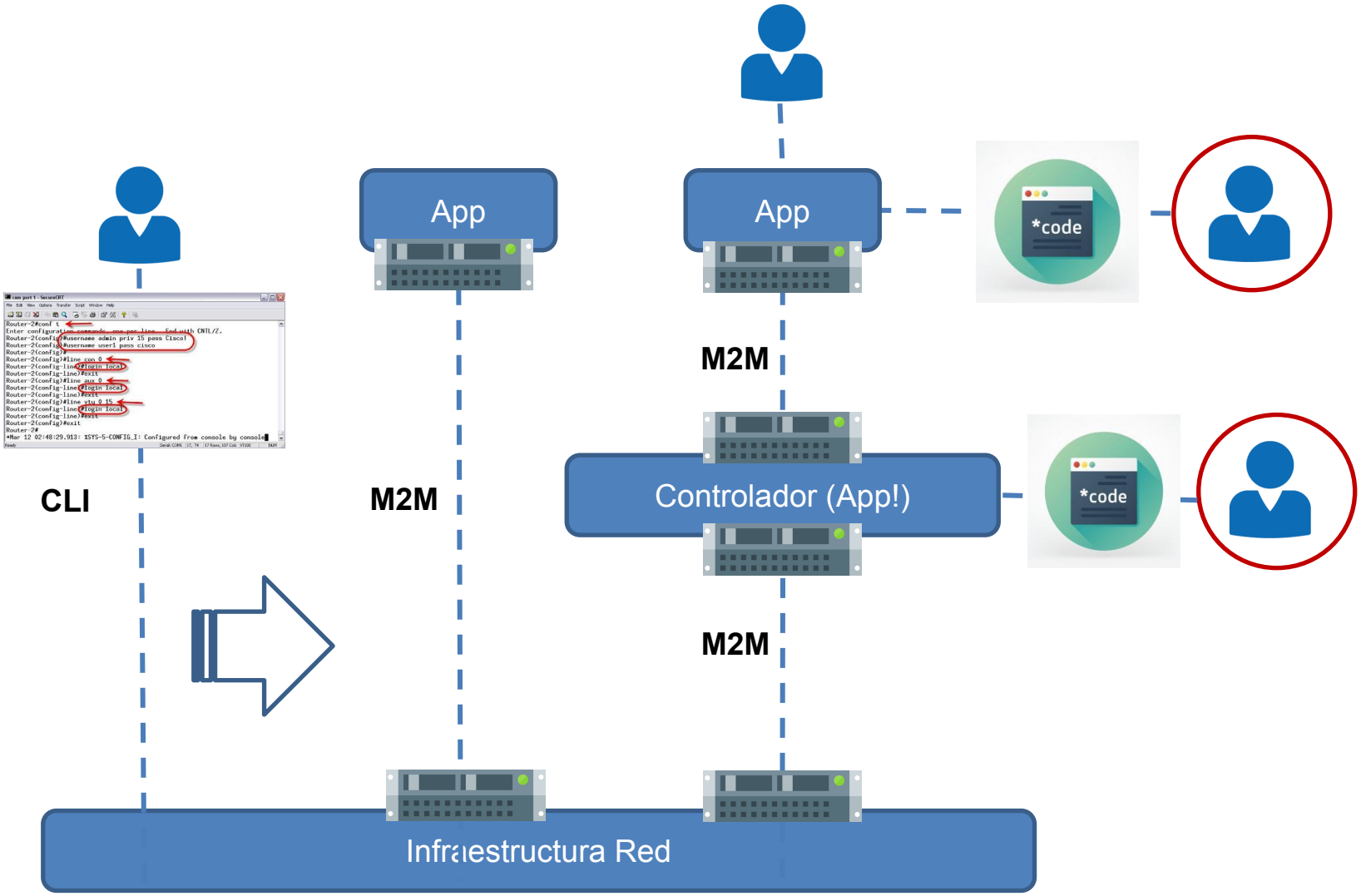
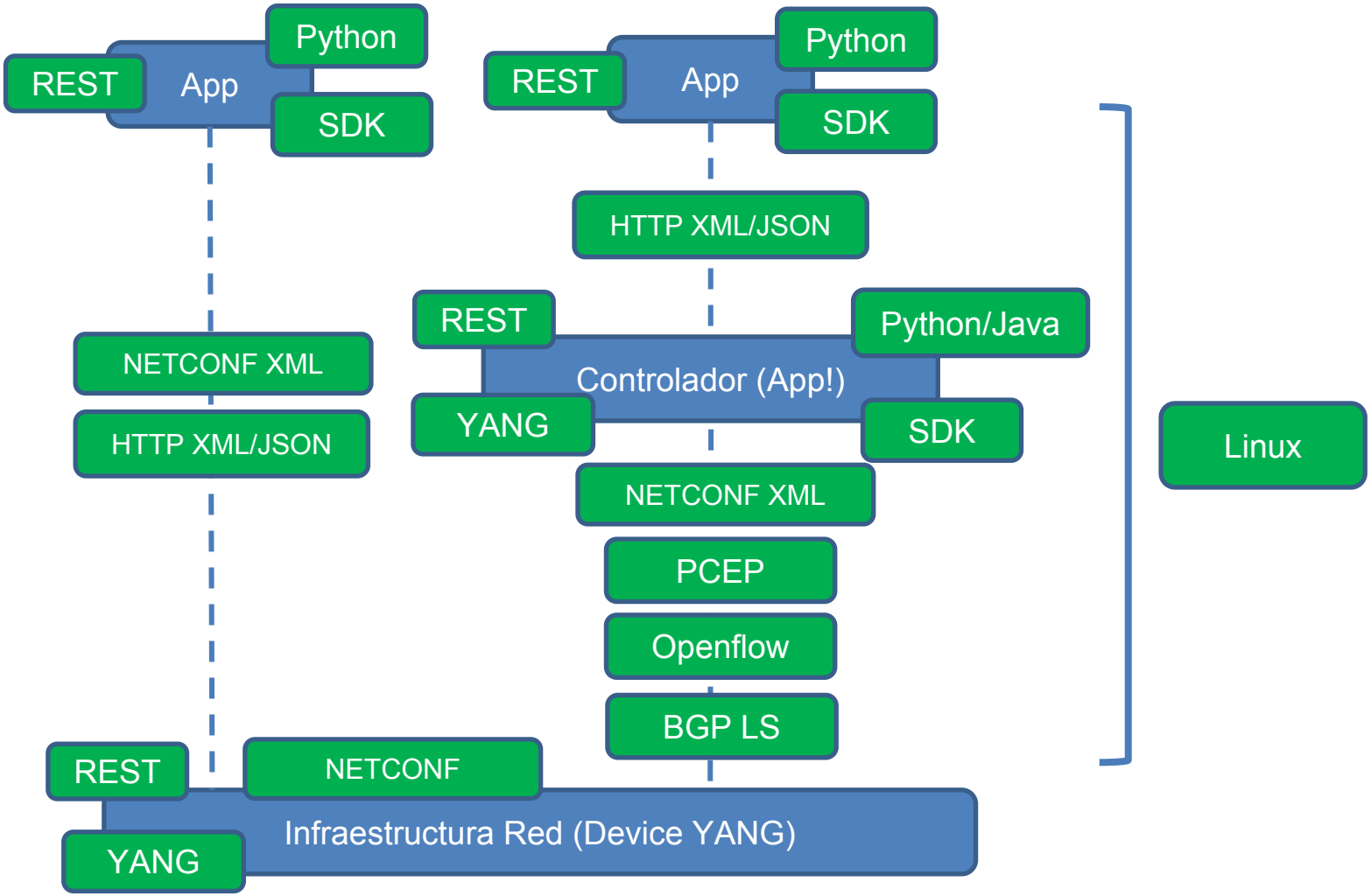
Poniendo las Piezas en Perspectiva



Poniendo las Piezas en Perspectiva



NETCONF

Principales Componentes

RFC 6241: “The NETCONF **protocol** defines a simple mechanism through which a network device can be managed, configuration data information can be retrieved, and new configuration data can be uploaded and manipulated”. **The protocol allows the device to expose a full, formal application programming interface (API).**

Modelo Cliente - Servidor (**RPC**) sobre **XML**

Operaciones ejecutadas mediante **Transacciones**

Data Stores, Config Data vs **Oper** Data

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Transacciones?

ACID

Atomicas: Todo o Nada

Consistencia: Conjunto de cambios, no una secuencia. Es decir, {A,B} y {B,A} producen el mismo resultado

Independencia: Transacciones en paralelo no interfieren entre sí, ocurren en secuencia.

Durables: Commit de la data perdura en el tiempo

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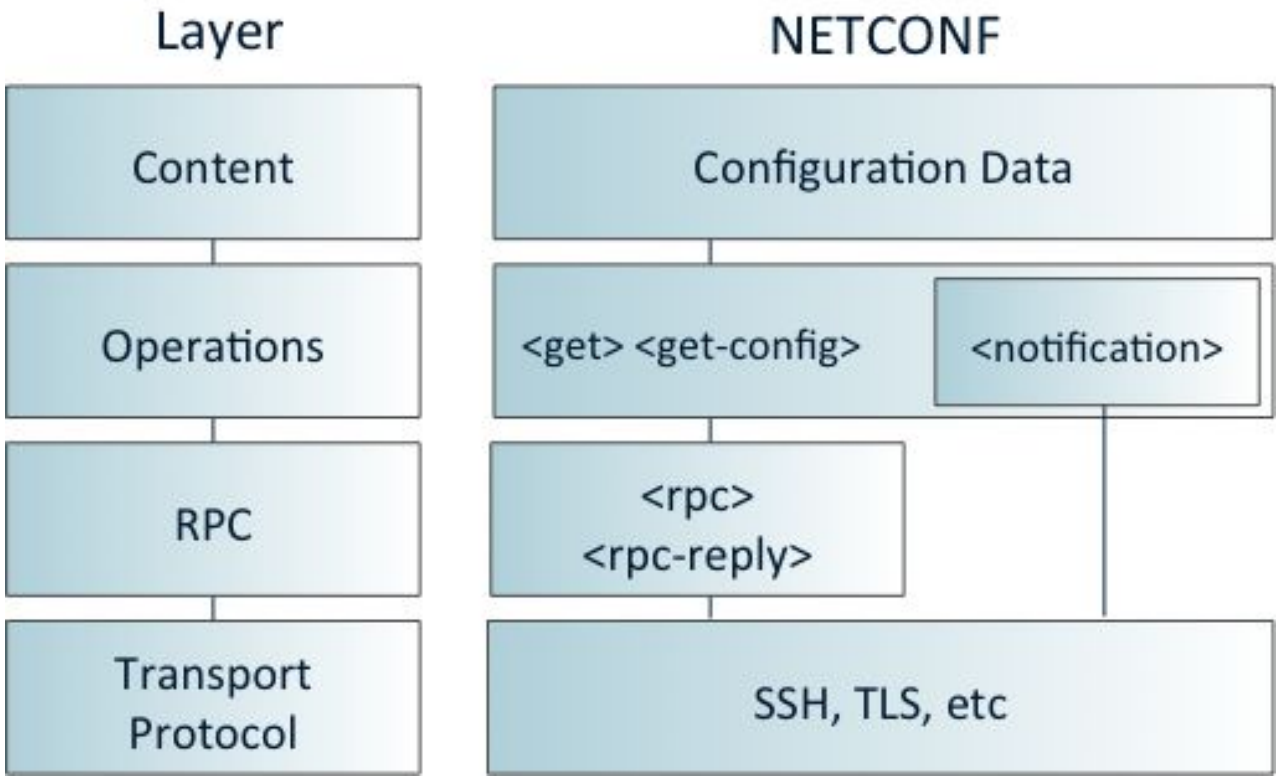
Estructura NETCONF



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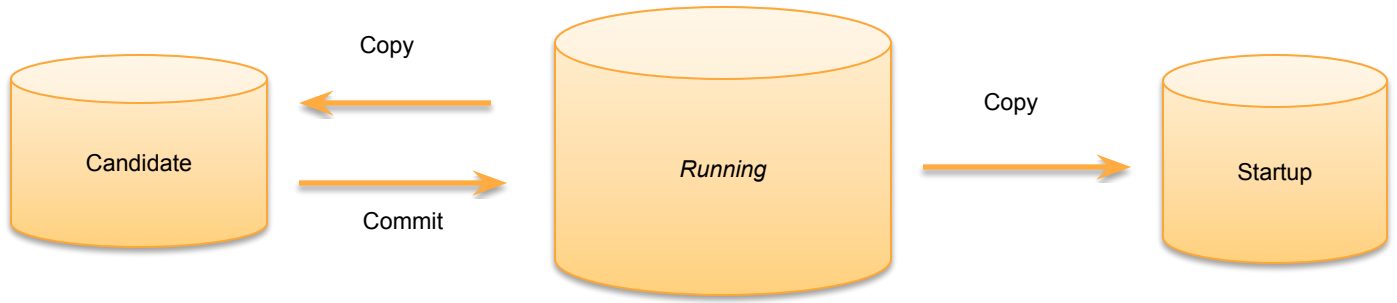
NETCONF Datastores



Permite manipular configuración sin ningún impacto en la configuración activa

(Mandatoria) representa la configuración activa

(Opcional) representa la configuración que se va a cargar cuando el dispositivo reinicie su operación

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Operaciones Comunes

Data Manipulation

<get> both config and oper data

<get-config>

<edit-config> over candidate for example

<copy-config> from runn to cand

<delete-config>

<discard-changes> *(:candidate)*

Session Management

<close-session>

<kill-session>

Locking

<lock>

<unlock>

Transaction Management

<commit> *(:candidate, :confirmed)*

<cancel-commit> *(:candidate)*

Schema Management

<get-schema> *(:monitoring)*

RPC Extensions

<rpc>

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NETCONF Ejemplo Configuración

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.1”   message-id="5" >
  <edit-config  xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0">
    <target>
      <candidate/>
    </target>
    <test-option>test-then-set</test-option>
    <error-option>rollback-on-error</error-option>
    <config>
      <interface xmlns=”urn:ietf:params:xml:ns:yang:ietf-interfaces">
        <name>eth1</name>
        <ipv4-address>192.168.5.10</ipv4-address>
        <macaddr>aa:bb:cc:dd:ee:ff</macaddr>
      </interface>
    </config>
  </edit-config>
</rpc>
```

```
<rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.1"
      message-id="5" >
  <ok/>
</rpc-reply>
```

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.1”   message-id="6" >
  <validate>
    <source>
      <candidate/>
    </source>
  </validate>
</rpc>
```

```
<rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.1"
       message-id="6" >
  <ok/>
</rpc-reply>
```

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.1”   message-id="7" >
  <commit>
    <confirmed/>
  </commit>
</rpc>
```

```
<rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.1"
       message-id="7" >
  <ok/>
</rpc-reply>
```

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YANG

Principales Componentes

RFC 6020: “YANG is a **data modeling language** used to model configuration and state data manipulated NETCONF, NETCONF remote procedure calls, and NETCONF notifications”.

Estructura Jerárquica: En forma de árbol: leaf, list, containers…
Tipos de Datos **Built-in y extensibles**
Data organizada en **módulos, extensibles, reusables**
NETCONF usa XML, como se relaciona con YANG?

```
list interface {
        key "name";
        unique "type location";

        leaf name {
          type string;
          reference
            "RFC 2863: The Interfaces Group MIB - ifName";
        }

        leaf description {
          type string;
```

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Model Driven API - YANG - Ejemplo

L3VPN

saintkepha / onos-l3vpn

Code | Issues 0 | Pull requests 0 | Projects 0 | Pulse | Graphs

Branch: master ▾ onos-l3vpn / ietf-l3vpn-svc.yang

saintkepha minor tweak to JSON.stringify differential output

1 contributor

1675 lines (1557 sloc) 38.5 KB

```
1   module ietf-l3vpn-svc {
2     namespace "urn:ietf:params:xml:ns:yang:ietf-l3vpn-svc";
3
4     prefix l3vpn-svc;
5
6     import ietf-routing {
7       prefix "rt";
8     }
9
10    import ietf-inet-types {
11      prefix inet;
12    }
13
14    import ietf-yang-types {
15      prefix yang;
16    }
```

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Ejemplo YDK Cisco

SDK API

```
from ydk.services import CRUDService
from ydk.providers import NetconfServiceProvider
from ydk.models.bgp import bgp

if __name__ == "__main__":
    provider = NetconfServiceProvider(address=10.0.0.1,
                                      port=830,
                                      username="admin",
                                      password="admin",
                                      protocol="ssh")
    crud = CRUDService()  # create CRUD service
    bgp = bgp.Bgp()  # create oc-bgp object
    bgp.global_.config.as_ = 65000  # set local AS number
    crud.create(provider, bgp)  # create on NETCONF device
    provider.close()
    exit()
```

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Linux IP Namespaces

De qué se trata

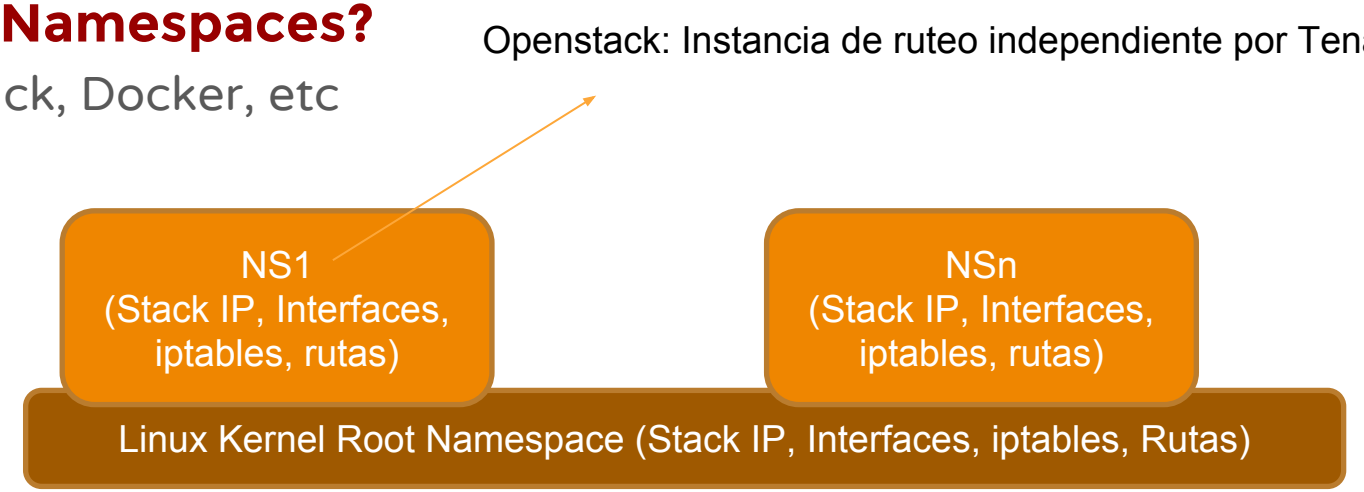
NS permiten que coexistan múltiples instancias de tablas de rutas en un mismo servidor Linux (ie, no se trata de crear nuevas VM)

Mediante NS es posible entonces segmentar o separar completamente dominios de red (interfaces, tablas de rutas, ip tables)

Similar a una VRF! segmenta espacios de ruteo

Quién Usa Namespaces?

Openstack, Docker, etc



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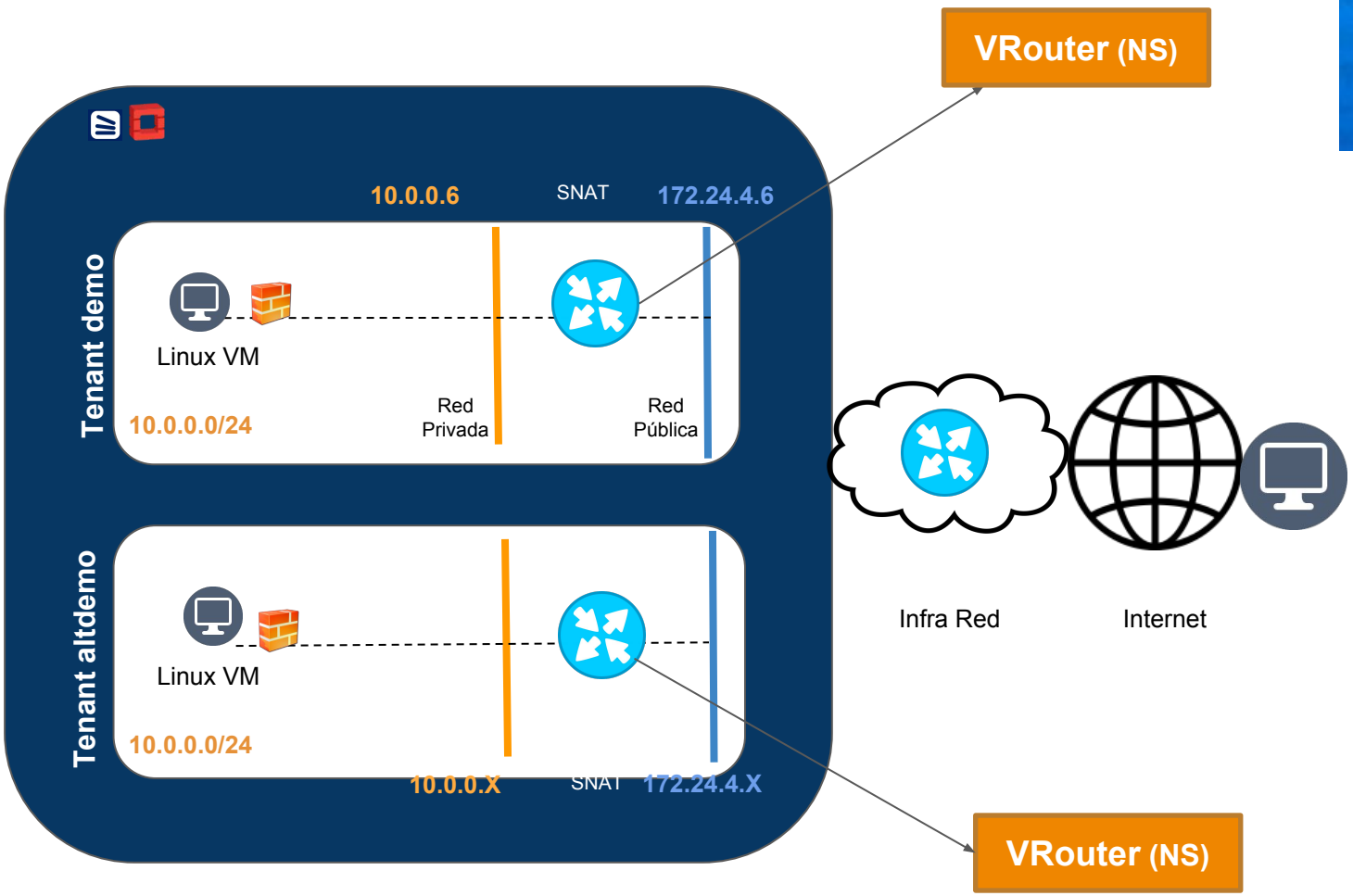
Demo Time! Namespaces en Openstack



Demo Time! Namespaces

Overview | Interfaces | Static Routes

Name router1

ID 273c6fe0-a1c2-48d6-bf60-a7ba740aad44

```
$ sudo ip netns exec qrouter-273c6fe0-a1c2-48d6-bf60-a7ba740aad44 ip address
```

router1

Overview | Interfaces | Static Routes

	Name	Fixed IPs	Status
☐	(3bc97eac-05c6)	• 2001:db8::7 • 172.24.4.3	Active
☐	(4560aac6-1d22)	• 10.0.0.1	Active
☐	(8b25595b-bfc7)	• fd0b:52a0:3d96::1	Active

```
41: qg-3bc97eac-05: <BROADCAST,MULTICAST,UP,LOWER
    link/ether fa:16:3e:3b:b9:e8 brd ff:ff:ff:ff
    inet 172.24.4.3/24 brd 172.24.4.255 scope glo
       valid_lft forever preferred_lft forever
    inet6 2001:db8::7/64 scope global
       valid_lft forever preferred_lft forever
    inet6 fe80::f816:3eff:fe3b:b9e8/64 scope link
       valid_lft forever preferred_lft forever
```

REST

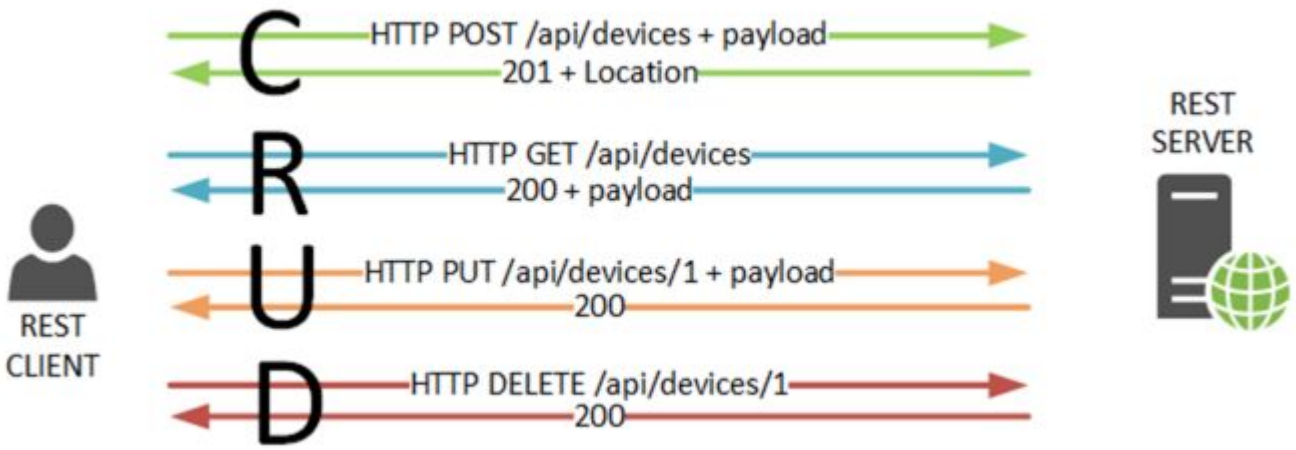
REpresentational STate

Estilo de arquitectura de SW para crear servicios web escalables

Basado en modelo cliente - servidor en donde se envían **requests** para identificar **resources** a través de **HTTP**

Soporte REST ⇏ Desarrollos Portables (Cada caso es cada caso)

Operaciones simples, similar (..) CRUD



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RESTCONF

Componentes

IETF Draft

ReSTful protocol para accesar data definida en YANG

Remote State Transfer: server maintains no session state

URI: Reflejan jerarquía de la data en un datastore NETCONF

HTTP as transport, No Locking / Operaciones simplificadas

Operations

RESTCONF	NETCONF
GET	<get-config>, <get>
POST	<edit-config> (“create”)
PUT	<edit-config> (“replace”)
PATCH	<edit-config> (“merge”)
DELETE	<edit-config> (“delete”)

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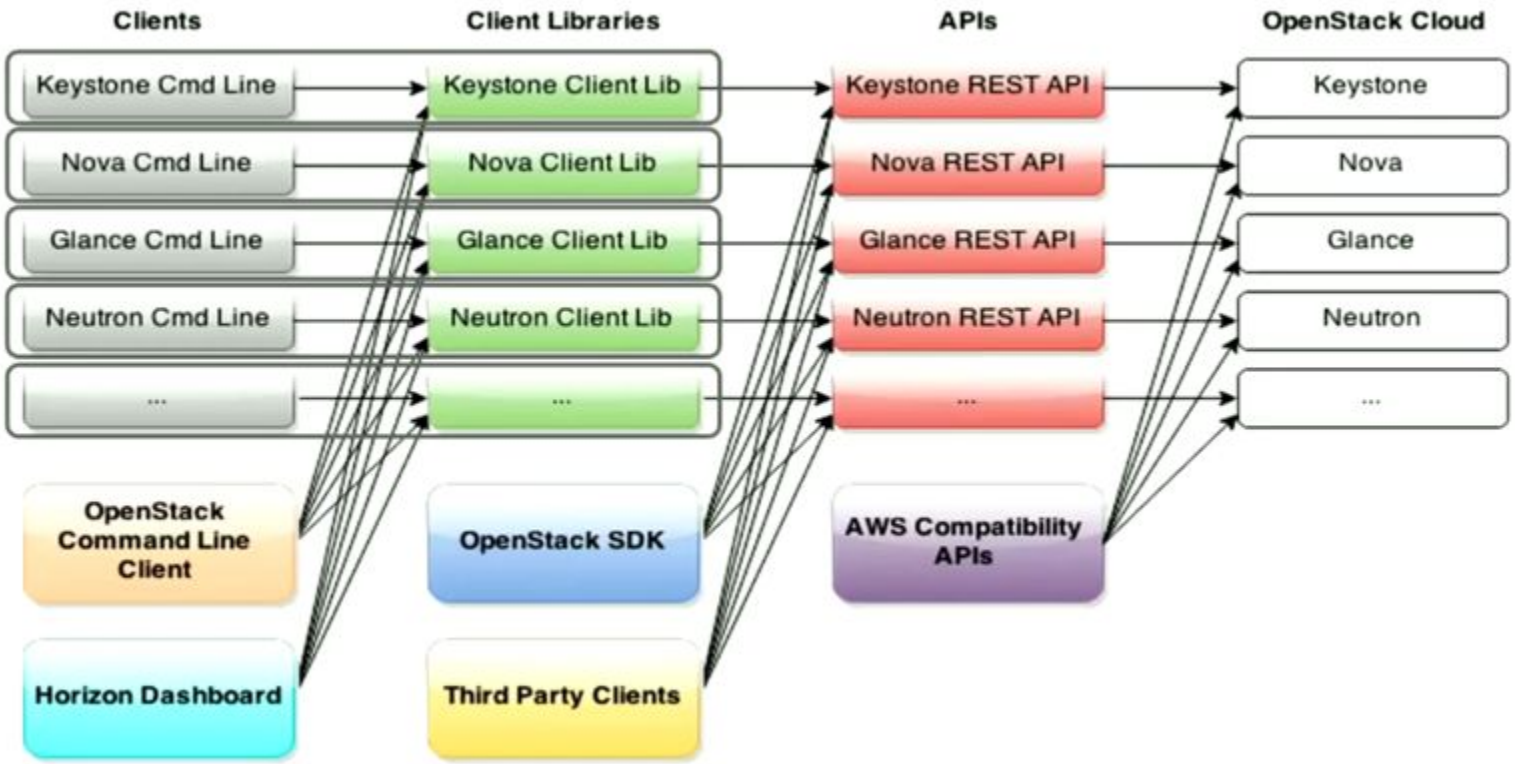
Ejemplo

“100 Ways to Openstack”



https://www.youtube.com/watch?v=oE1OrJCpiNY

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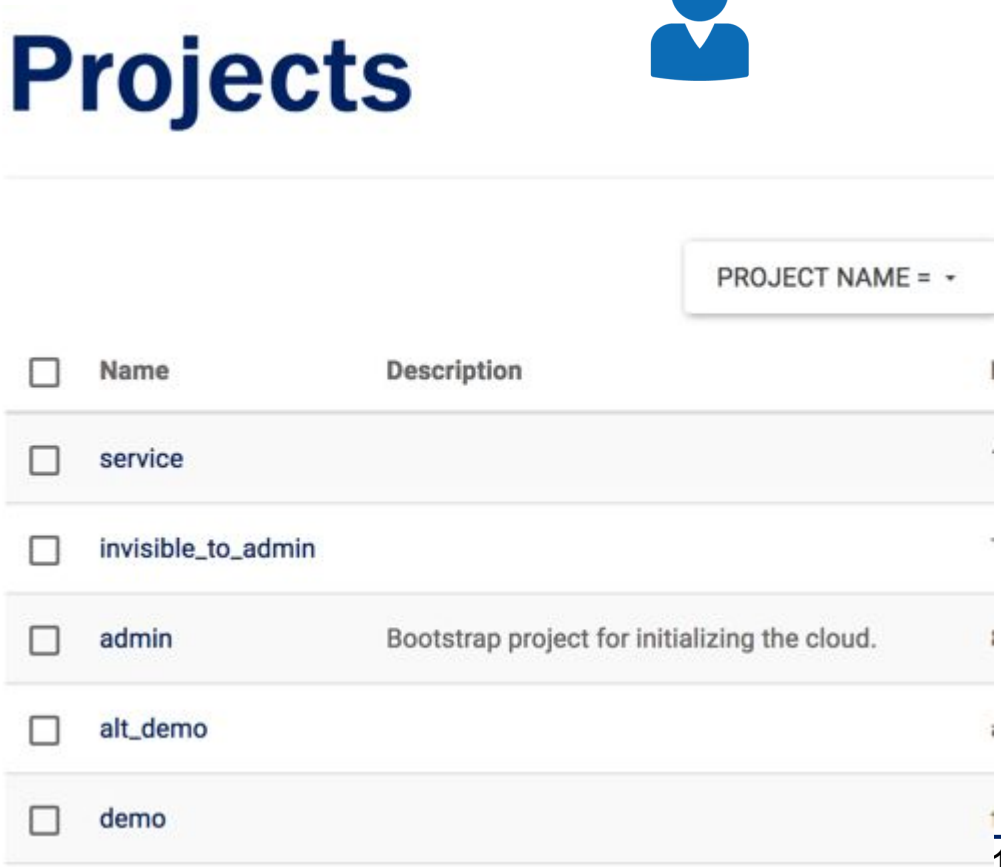
Demo Time!!

REST & Python & Openstack

Objetivo: Obtener en forma programática el listado de todos los tenants de nuestra instalación de openstack

1. REST mediante CURL
2. REST mediante Python
3. Openstack SDK



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En resumen, qué hemos visto

Shift o re-skilling del ingeniero de red tradicional

- Incorporar nuevas tecnologías y prácticas que apunten a dar programabilidad a la red
- Mix munddo TI + Networking
- Desafío personal y organizacional para los SP
- Por doónde comenzar: Linux, APIs (REST), Lenguaje Programación (Python)

Network Programmability : Arquitectura

- Importante entender el contexto y diferentes componentes
- Desarrollar Arquitectura requiere poner atención a su apertura y facilidades de programación
- APIs deben estar bien documentadas y entregar herramientas para su consumo/soporte

Revisamos algunos elementos importantes y ejemplos prácticos

- NETCONF / YANG
- Linux everywhere, en particular Networking (LB, NS) aplicado a Openstack
- Openstack SDK
- REST aplicado a Openstack (CURL y PYTHON)

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