Redes de Datos

De entes físicos a procesos software en entornos virtuales

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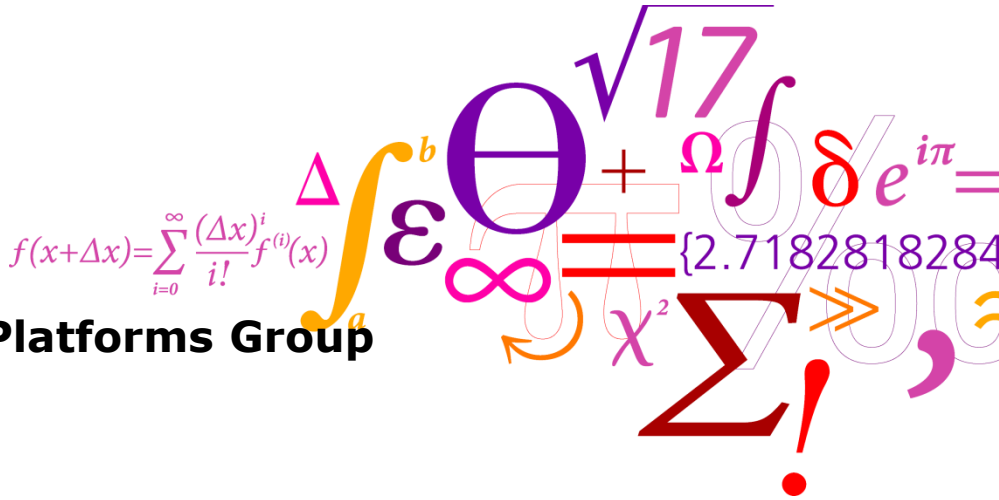


Networks Technology & Service Platforms Group
DTU Fotonik
Institut for Fotonik

Descarga y Presentación

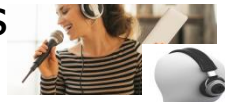
Image Sources:
http://www.bestbuy.ca/en-ca/category/blenders/26544.aspx
http://antoncastro.blogia.com/2006/081502-el-humor-de-alberto-calvo-el-alter-ego-de-supermano.php
http://www.lonelyplanet.com/maps
https://www.sunflystreaming.com/
http://www.s144.ca/networks
http://www.wallpaperup.com/696410/tren_ave_ferrocarril.html

- Opinion personal (non UCM, non DTU – a pesar del formato).
- Reuso de materiales → mezcla de estilo e Inglés.

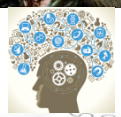
- Ingeniero Superior de Telecomunicaciones (U. Zaragoza).



- Integración & Investigación en redes y servicios
  - Streaming, VoIP, IMS, SDN, ERTMS, …
  - "Rolling Stone" (culo de mal asiento)



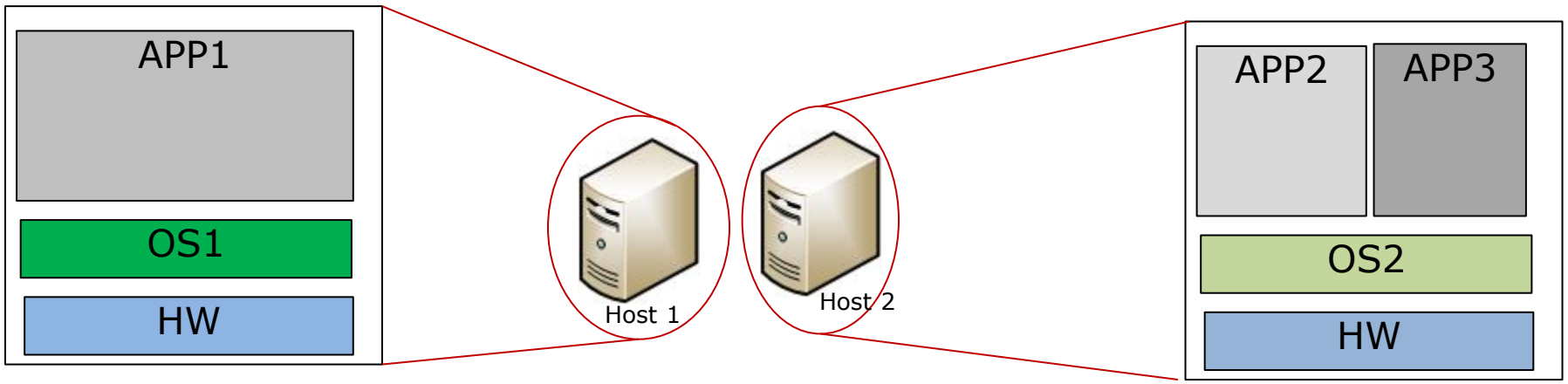

- Actualmente: Univ. Técnica de Dinamarca
  DTU Fotonik
  Grupo de Tecnología de Red y Plataformas de Servicios



Agenda

- ✓ Descargo de responsabilidad y Presentación.
- ✓ Virtualización de Equipos (Host).
- ✓ Redes de Datos convencionales. Problemática.
  - SDN como solución.
- ✓ SDN en cuatro diapositivas.
- ✓ El problema de los equipos intermedios (middle-boxes)
  - NFV como solución .
- ✓ Arquitecturas NFV. Estandarización.
- ✓ Ejemplos de casos de uso.
- ✓ Propuestas de código abierto.
- ✓ Futuribles.
- ✓ Conclusión.

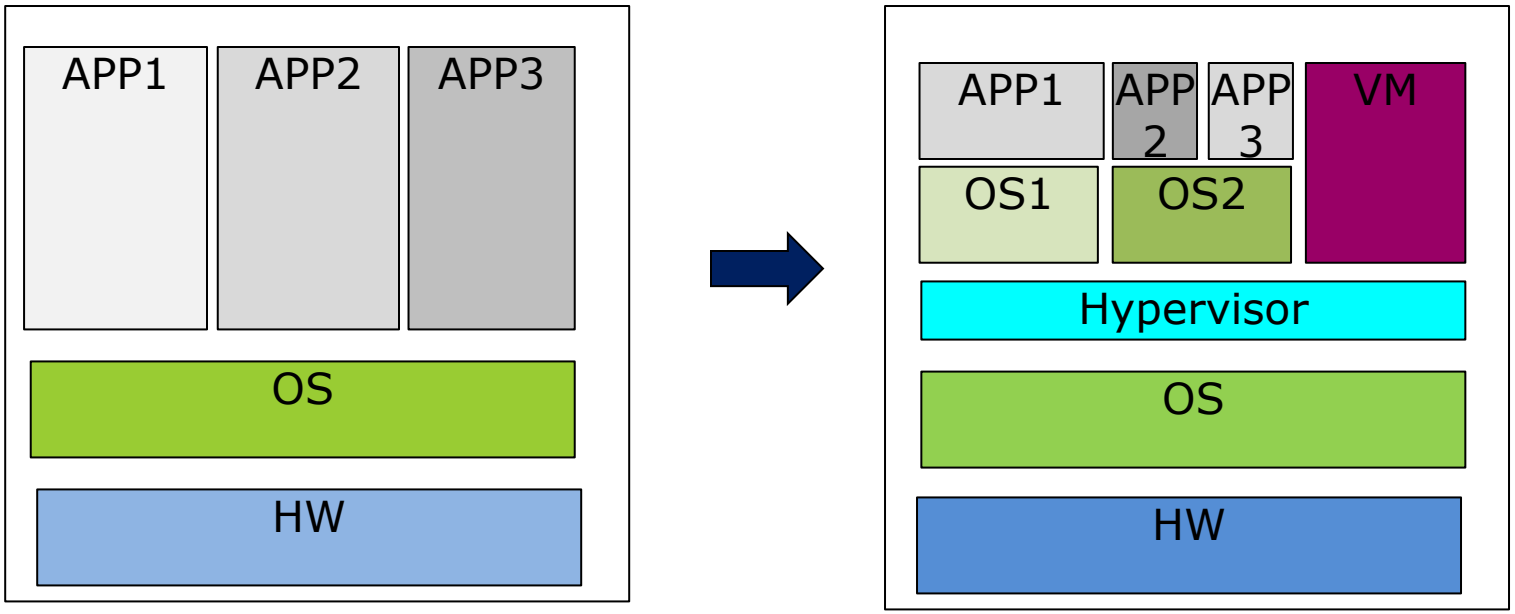
Server virtualization. Why?



f.ex. : Laptop running Linux + Laptop running Windows

- Non scalable: hardware resources / el. consumption / room
- Non portable: replicability limited by scalability

Server virtualization (Type 2 hypervisor)



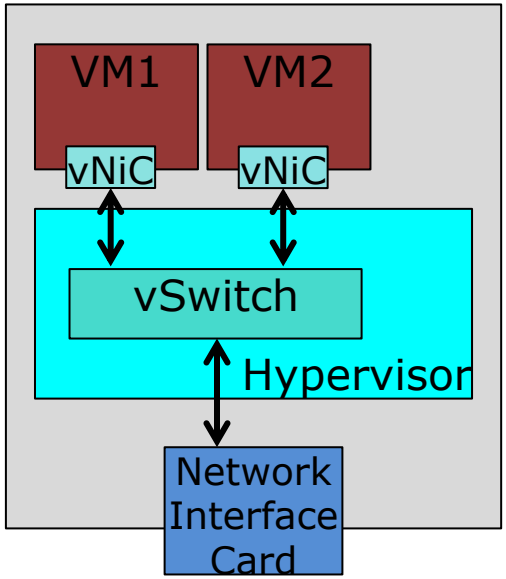
Hypervisor as manager of (underlying) resources → Virtual Machines. (VMs)

- ✓ Maximize utilization of HW resources.
- ✓ Minimize El. Consumption.
- ✓ Increased flexibility (VMs managed as “files”): copy, launch, …

Networking Virtual Machines (in 1 slide ☺)

The hypervisor provides for:

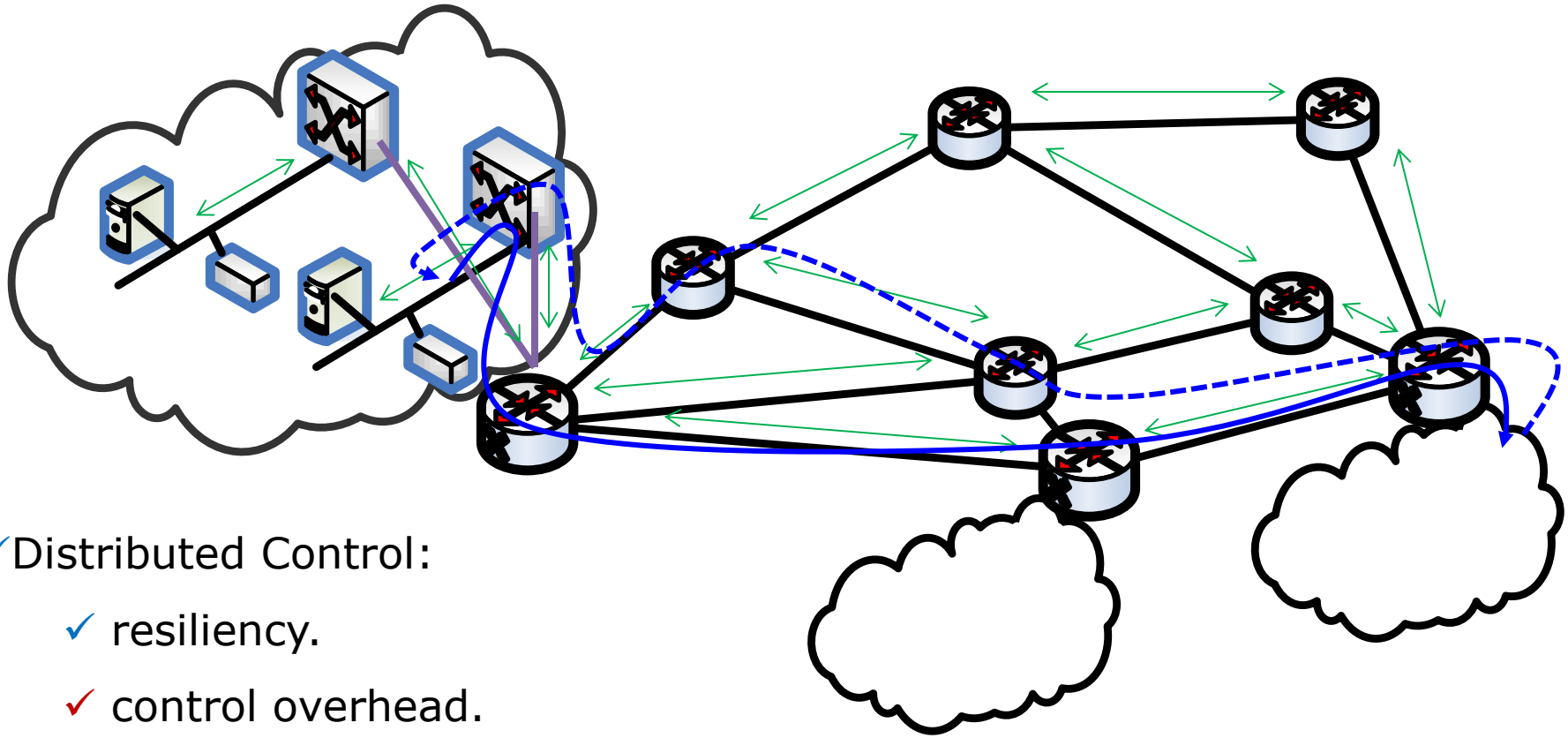
- ✓ Co-located VM inter communication.
  - ✓ Switched LAN
- ✓ (transparent) External communication.



- Internal hypervisor ”mapping” mechanisms, at network level, can impact performance.

(Conventional) Data networks: distributed control

✓ Control vs Data paths

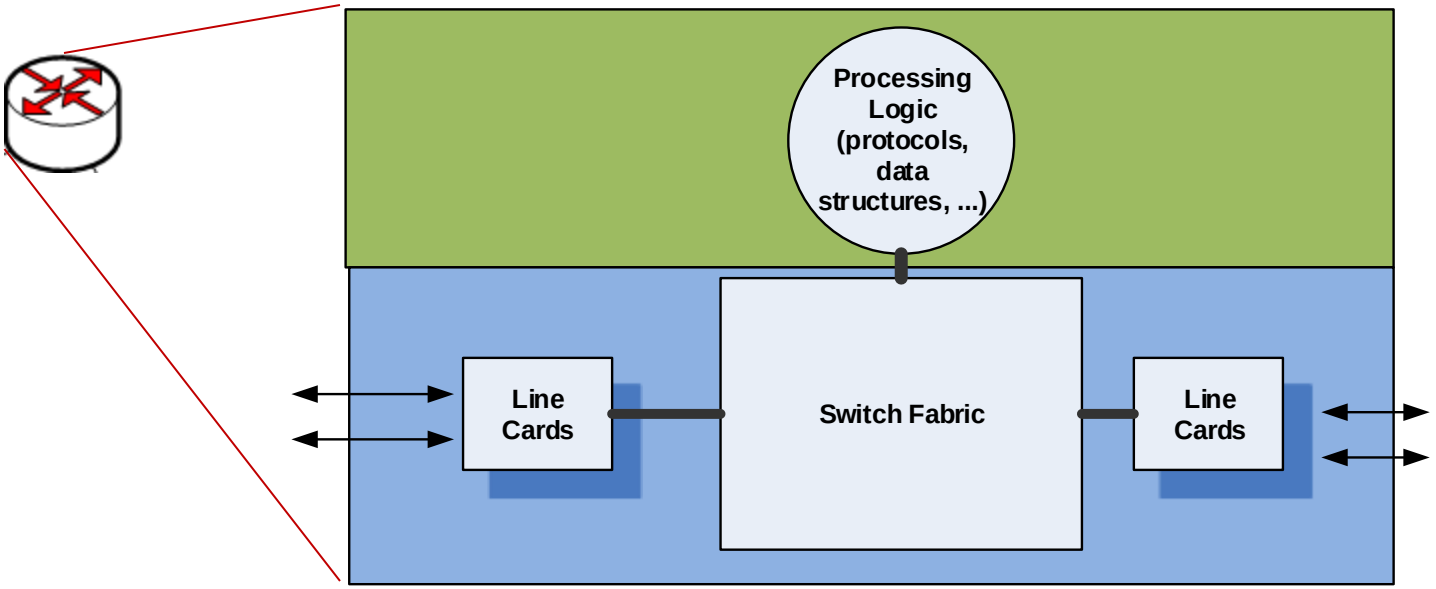


✓Distributed Control:

- ✓ resiliency.
- ✓ control overhead.
- ✓ convergence time.

Conventional Network Elements: Ctrl/Fwd in-box coupling

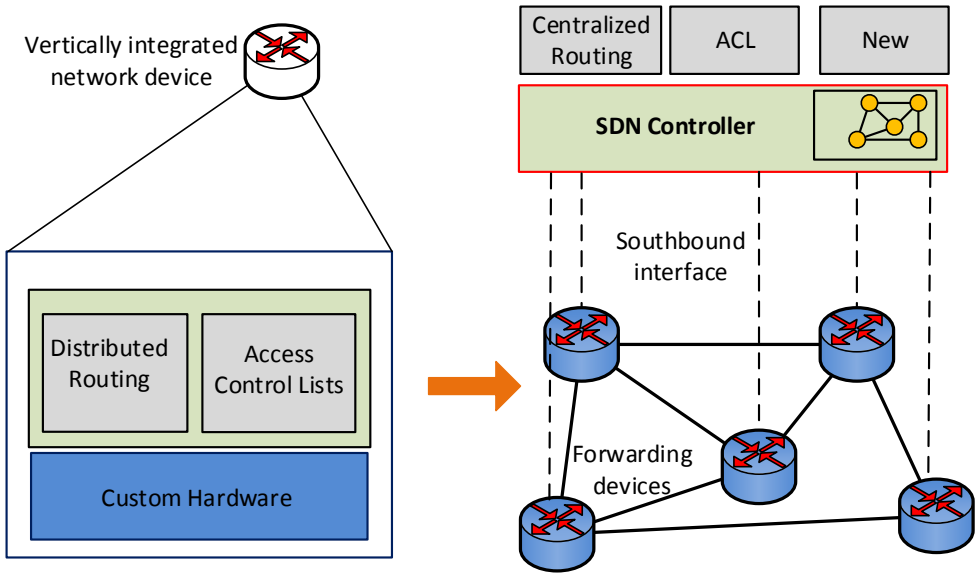
- ✓ Control vs Data (forwarding) planes in Nt elements



- ✓ Tight coupling / integration:
  - ✓ efficiency
  - ✓ reduced programmability → modifications, innovation, …
  - ✓ reduced scalability → changes in all deployed units, …

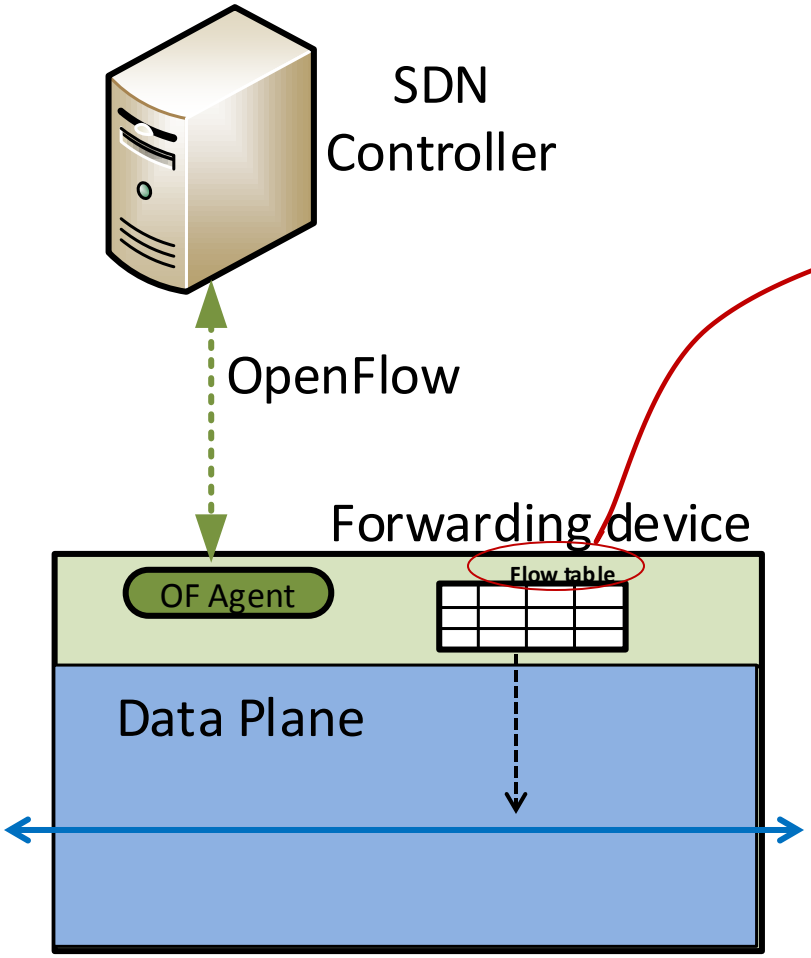
Software Defined Networking (SDN)

"The physical separation of the network control plane from the forwarding plane, and where a control plane controls several devices." ONF.



- ✓ abstracting the forwarding functions
- ✓ pulling the control functionality out of the box
- ✓ centralizing & automating

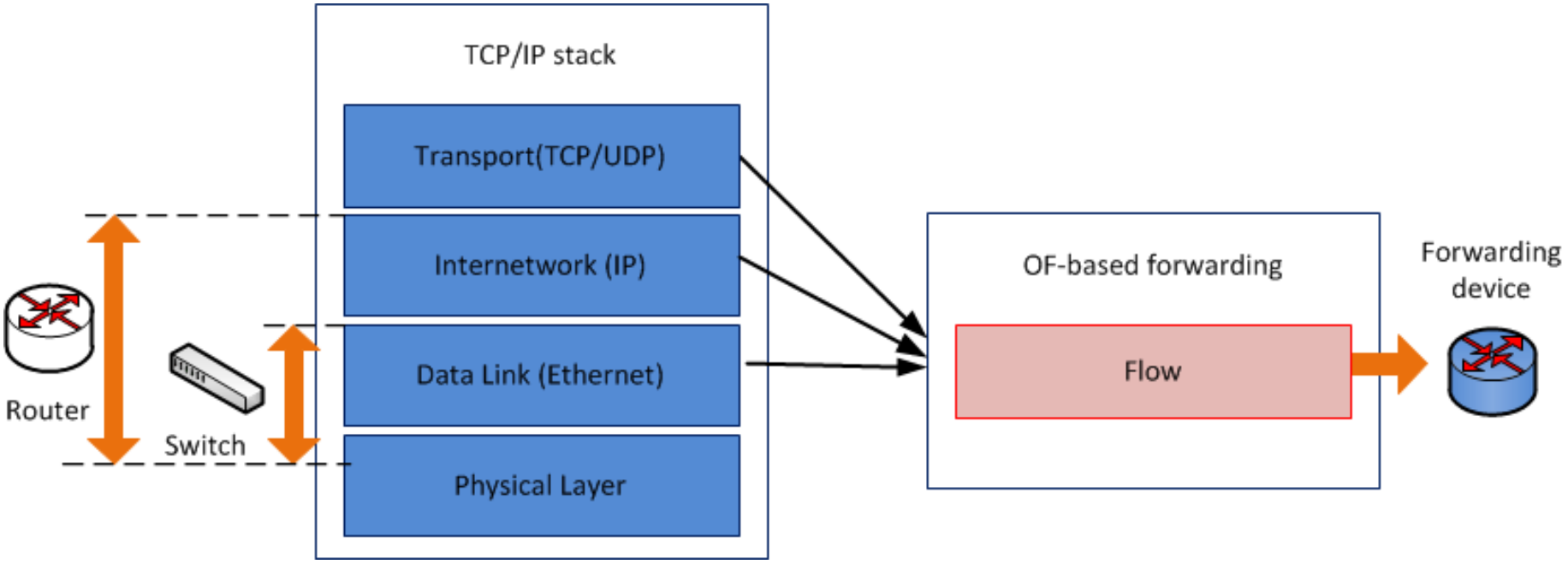
SDN: OpenFlow - Flow table and matching (OF 1.0)



Header Fields	Counters	Actions	Priority
Ingress Port Eth. Source Addr. Eth. Dest. Addr. Ethernet Type VLAN id VLAN Priority IP Source Addr. IP Dest. Addr. IP Protocol IP ToS ICMP type ICMP code	Per Flow Counters Received Packets Received Bytes Duration seconds Duration nanosecconds	Forward Enqueue Drop Modify-Field	

Source: Open Flow Switch Specification v1.0

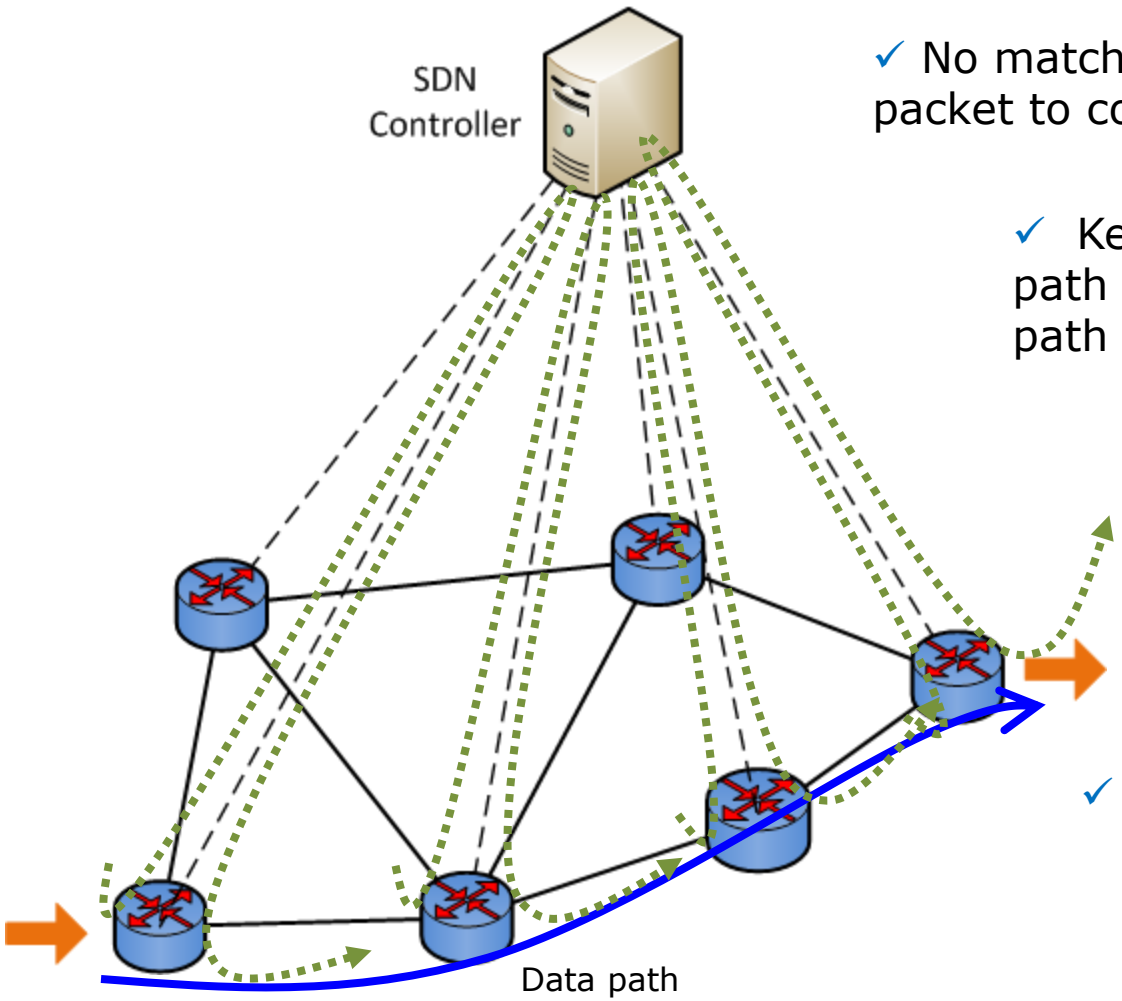
SDN: Flow based forwarding



Traditional Forwarding Device: hubs, switches, routers, …

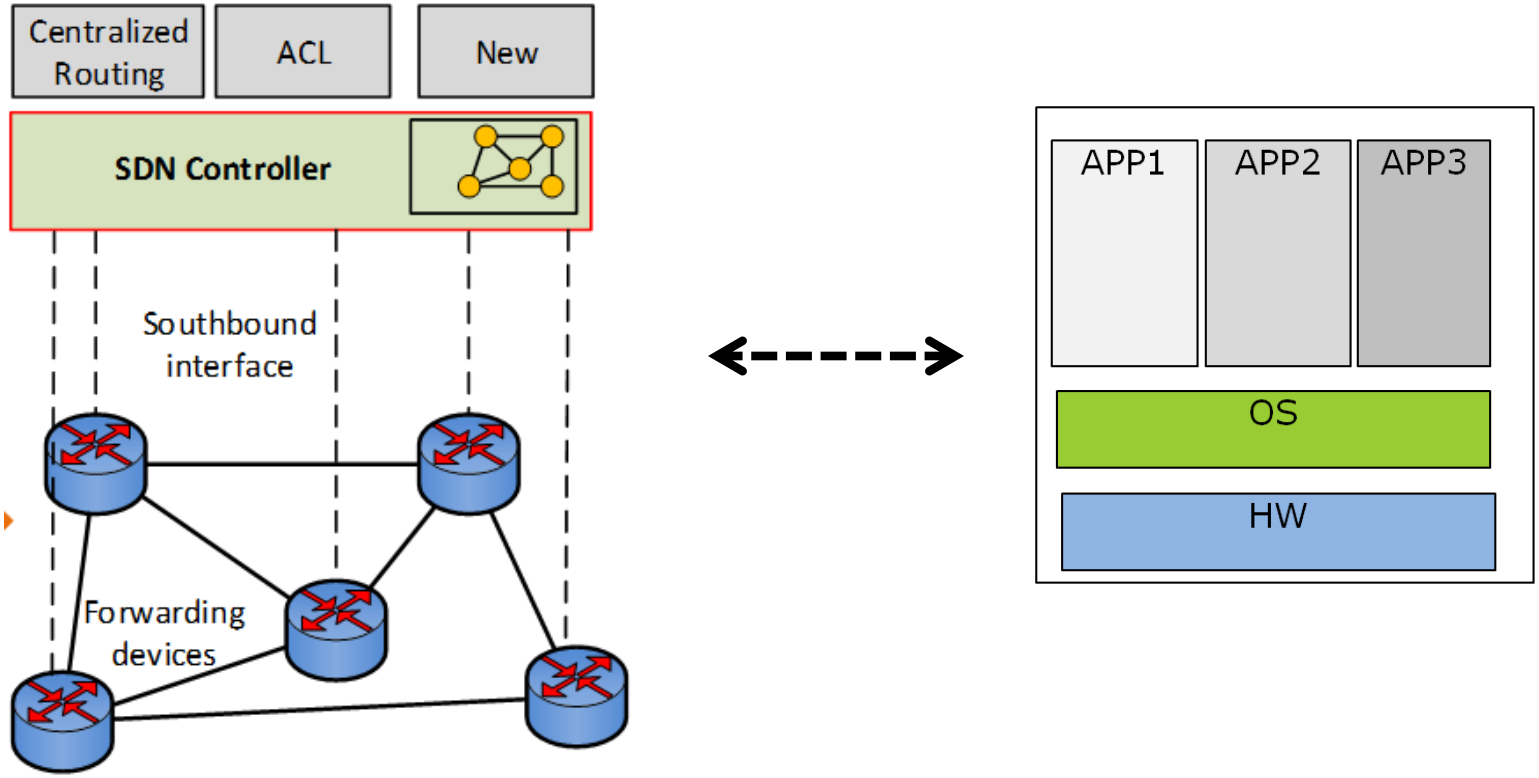
SDN-based Forwarding Device

SDN: Fast (data) vs. Slow (control) path

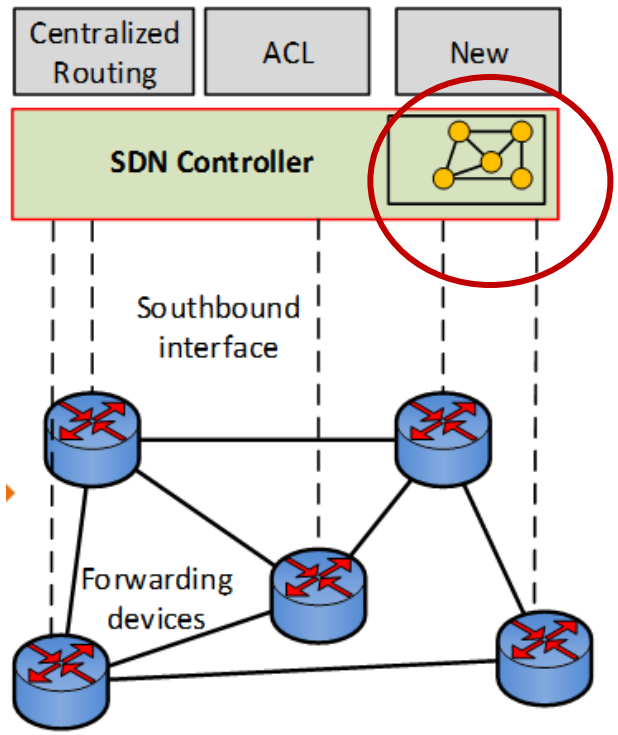


- ✓ No match in the flow table -> forward packet to controller
- ✓ Keeping the data flows in the data path speeds up the forwarding (initial path set-up).
- ✓ reactive vs. proactive

SDN: The controller as the ”Network OS”



SDN: The controller as the ”Network OS”



✓ Besides connectivity management SDNC provides other services to apps (by periodic pulling the network elements):

- Link/Device utilization.
- Application usage

…

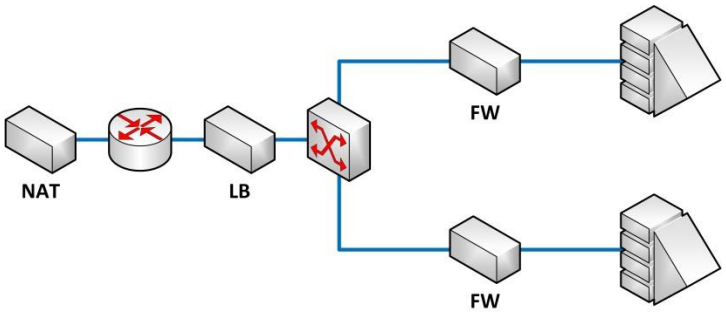
✓ SDNC maintains a representation of Network State

→Dynamic Local/Global optimization:

- Load balancing
- Rerouting
- Restoration
- …

Network Functions Virtualization (NFV) I

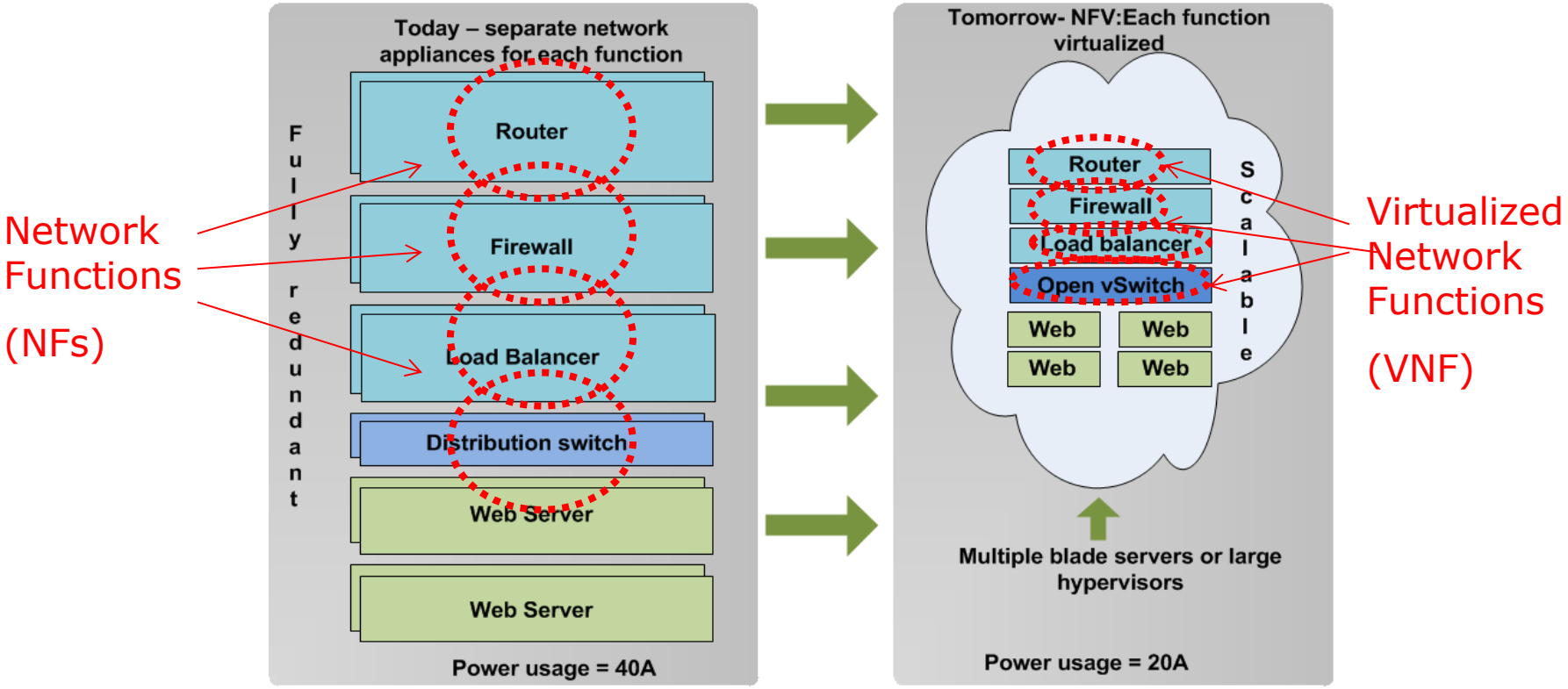
- ✓ Concept initiated by service providers.
- ✓ A considerable number of specialized boxes in the network, processing packets: middle-boxes/appliances.
  - ➢ Firewalls, NATs, Load Balancer, Deep Packet Inspection, etc.
  - ➢ (Network Functions) = components of a network service.



- ✓ These specialized middle-boxes are:
  - ➢ hard to manage
  - ➢ consume a lot of power
  - ➢ not a scalable solution

Network Functions Virtualization (NFV) II

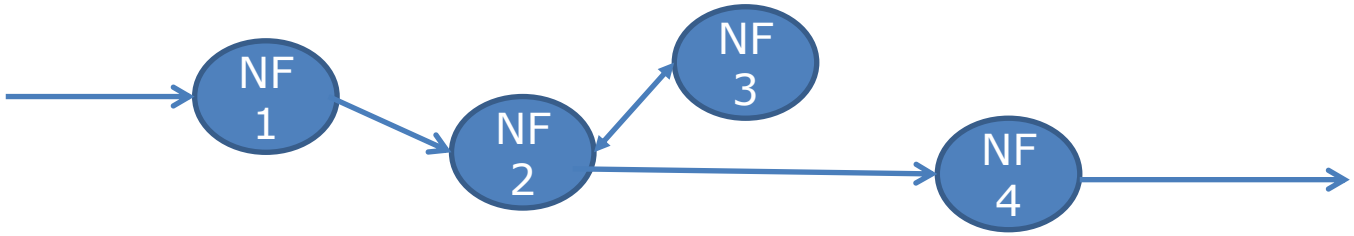
- ✓ Solution: Run all NFs on commodity hardware, in a virtualized environment (virtual machines, data center).



Source: http://wikibon.org/wiki/v/Network_Function_Virtualization_or_NFV_Explained

NFV + SDN: service chaining

- ✓ How can SDN help ?
- ✓ Traffic flows need to be routed through NFs.
- ✓ SDN controller enables their chaining.



→(programatic) policy-based management.

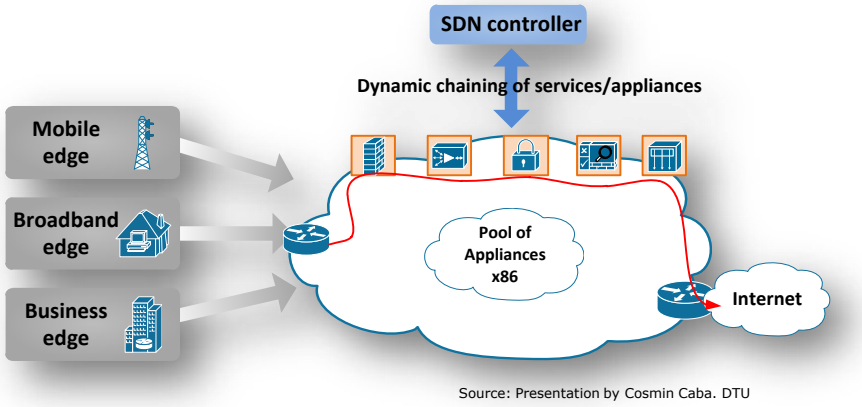
→(escalable) at NF level or chain level.

NFV + SDN: recap

- ✓ SDN → network centralized control & programmability.
- ✓ NFV → scalability & flexibility (SW instead of HW).

+

Services Scalability, Flexibility, Composition, new possibilities

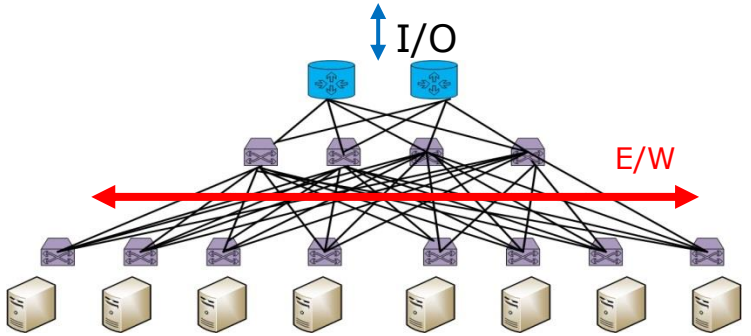


Source: Presentation by Cosmin Caba. DTU

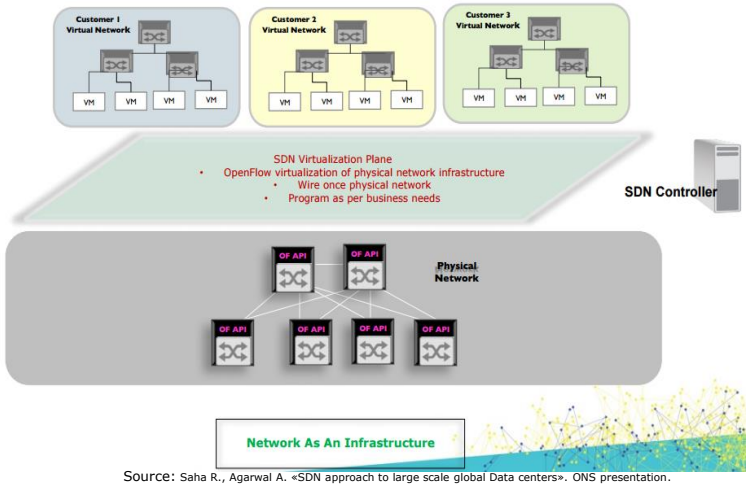
Innovation?

- ✓ This trend is not new: Data Centers & the Cloud.

Source: http://images.fatcow.com/data-center-photos/new/ReliableWebHosting.jpg



- ✓ SaaS / IaaS /PaaS
- ✓ Amazon WS, MS Azure, Google…
- ✓ Proprietary (closed) solutions.



Source: Saha R., Agarwal A. «SDN approach to large scale global Data centers». ONS presentation.

Innovation?

- ✓Telecommunication services heavily based on hardware infrastructure.
- ✓Paradigm shift:
  - ✓From a distributed set of linked hardware boxes.
  - ✓To software components running in Data Centers.

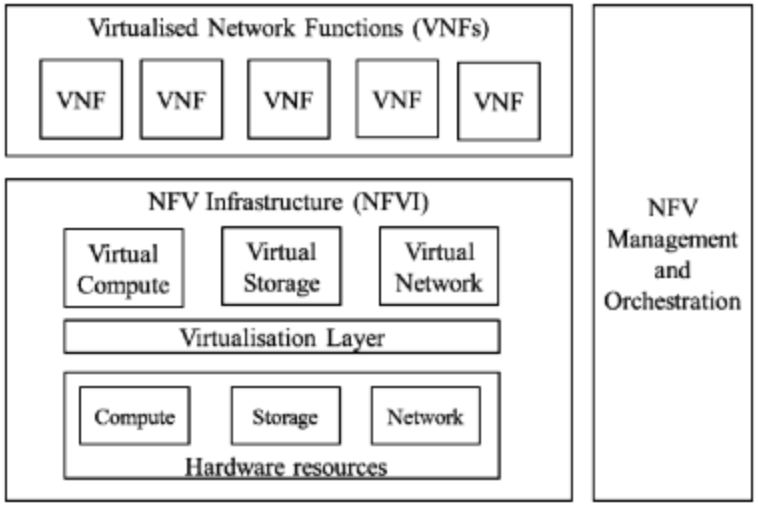
Note: consider the impact of this in relevant industry actors (i.e. Cisco, Alcatel (Nokia), Huawei..?) which see their business opened to new entrants or worse the open source community to provide freely similar services over off-the-self hardware…

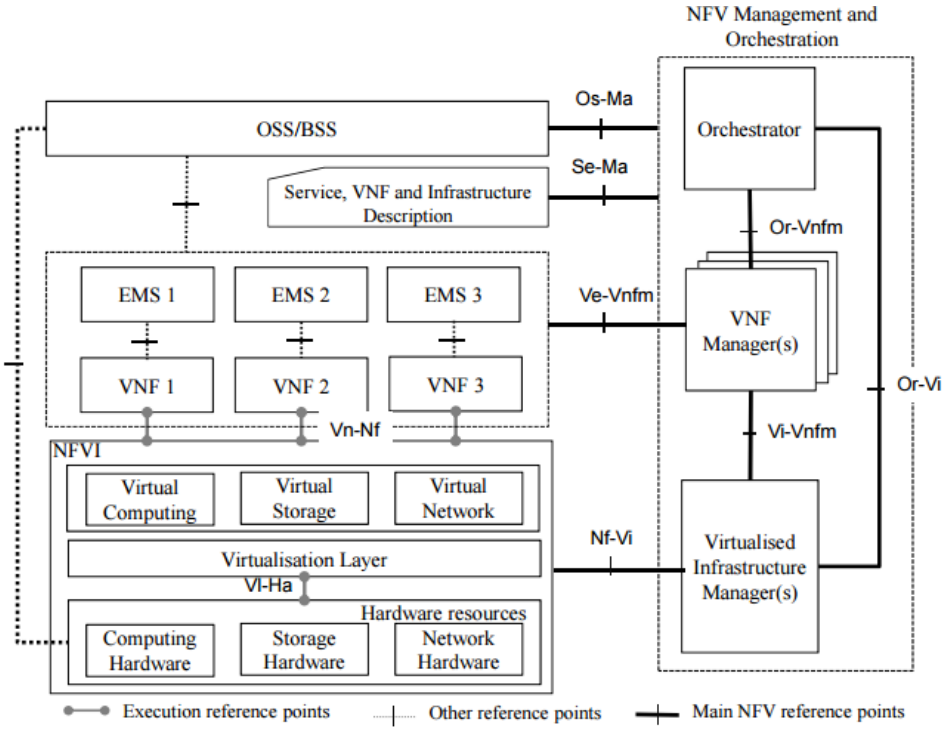
- ✓ Need for interoperability → standardization.
- ✓ Similar needs to DC/Software industry? → discussed later.

NFV Standardization - ETSI

- ✓Reference architecture

http://www.etsi.org/technologies-clusters/technologies/nfv

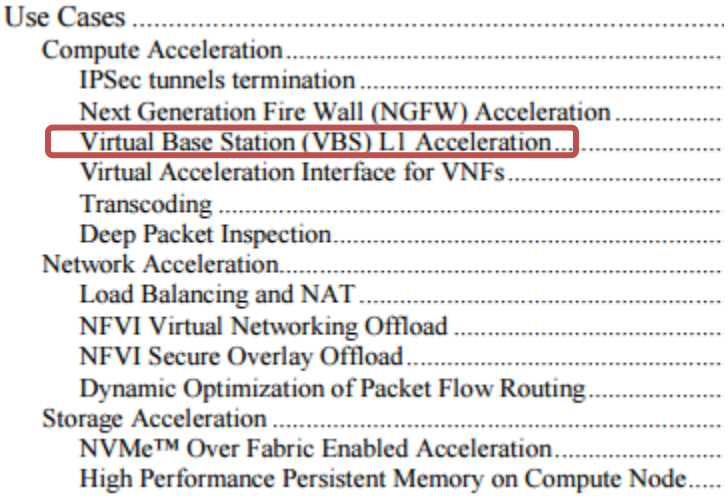




Images Source: ETSI GS NFV 002 - http://www.etsi.org/deliver/etsi_gs/nfv/001_099/002/01.01.01_60/gs_nfv002v010101p.pdf

NFV Standardization - ETSI

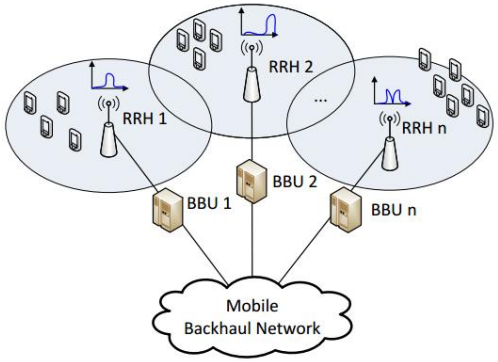
✓Use cases

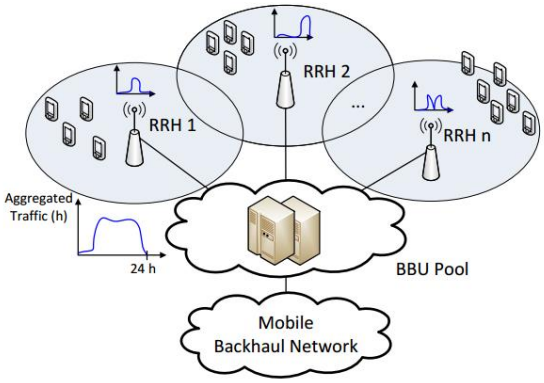


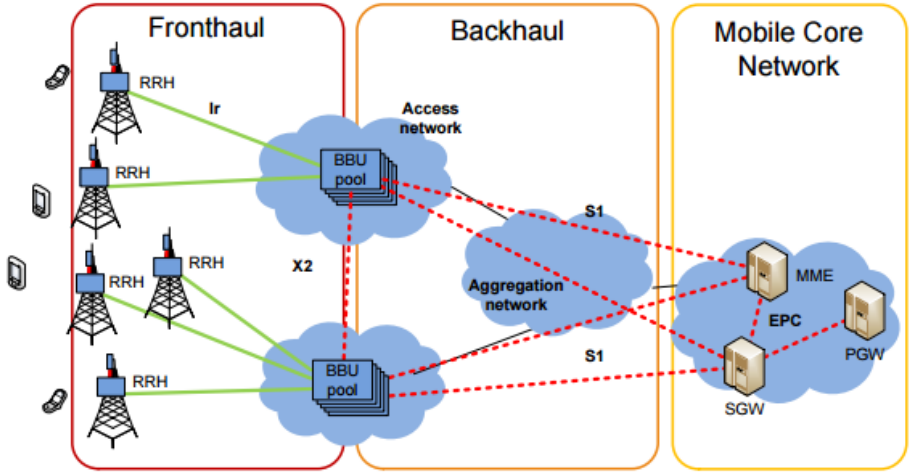
= Cloud RAN

Images Source: ETSI GS NFV 001 - http://www.etsi.org/deliver/etsi_gs/NFV-IFA/001_099/001/01.01.01_60/gs_NFV-IFA001v010101p.pdf

NFV - In the Radio Access: CloudRAN







Images Source: A. Checko et alt.: *Cloud RAN for Mobile Networks, a technology overview. IEEE Communications, surveys and tutorials. DOI:* 10.1109/COMST.2014.2355255

Generalizing the NFV model

- ✓ VNF granularity…any limit?
  - Micro components (FW, NAT, LB, eNB…)
  - Macro components (EPC, IMS, …)

Let’s consider the case of LTE’s EPC….

Control vs Data Plane in LTE

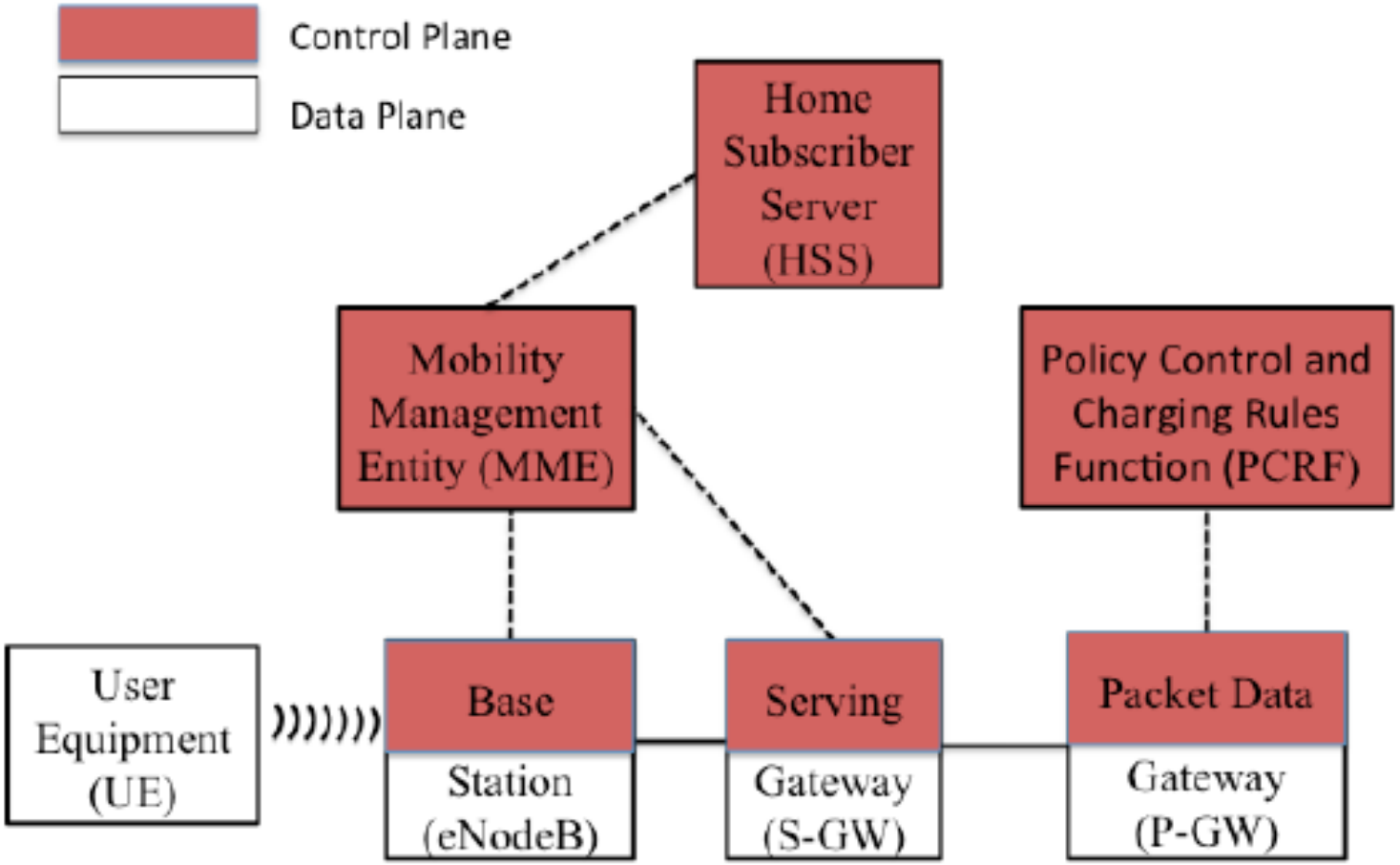


Image Source: Li, Mao & Rexford, "Toward SD Cellular Networks". Proceedings EWSDN, Darmstad, Germany, 2012.

Technology–based network slicing

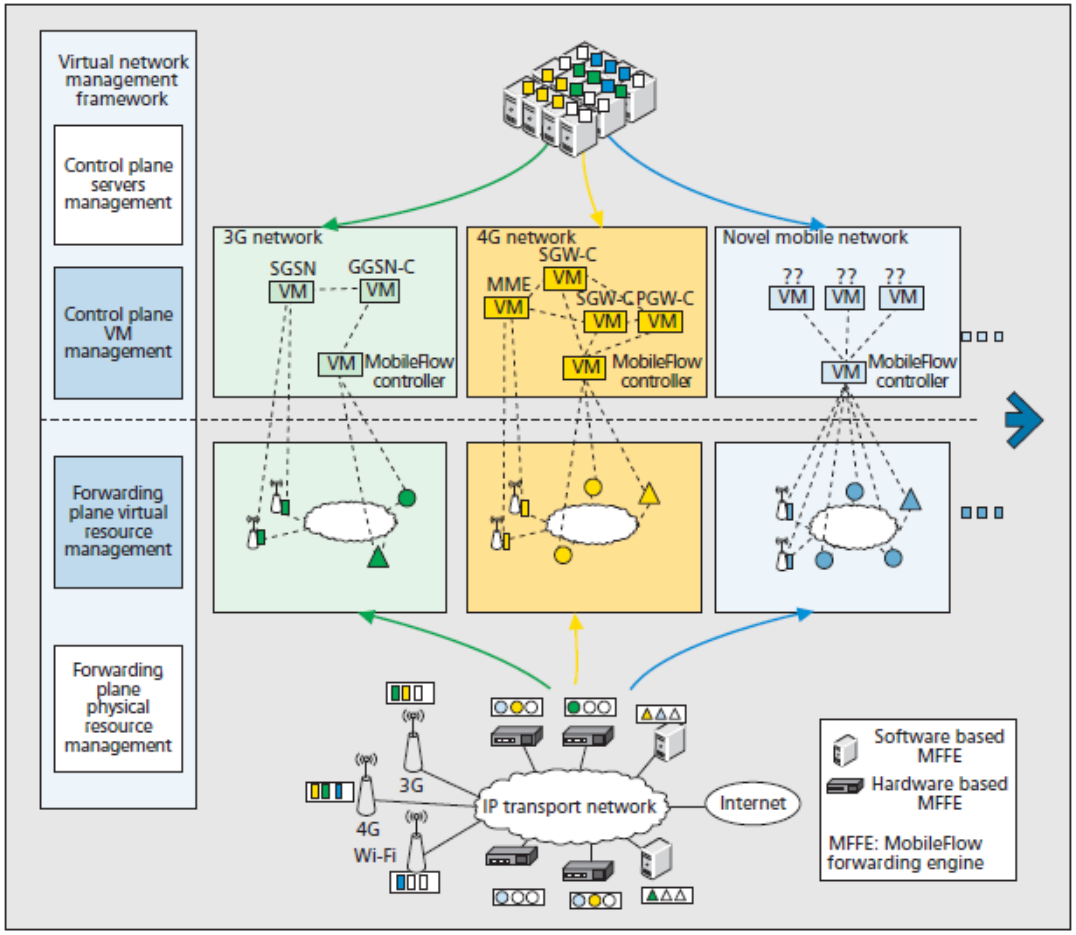


Image Source:

Kostas Pentikousis et. al., *MobileFlow: Towards Software-Defined Mobile Networks. IEEE Communications Magazine – July 2013*

Vendors of vEPC products (illustrative)

- Brocade: http://www.brocade.com/en/products-services/mobile-networking/vepc.html
- NEC: http://www.nec.com/en/global/solutions/tcs/vepc/
- NOKIA: http://insight.nokia.com/vepc-lte-networks-time-move-ahead

http://www.tmcnet.com/tmc/whitepapers/documents/whitepapers/2014/10743-alcatel-lucent-virtualized-epc-delivering-the-promise-nfv.pdf

- Affirmed: http://www.affirmednetworks.com/products-solutions/vepc/
- OpenEPC: http://www.openepc.com/

...

- **OPEN SOURCE** : http://www.openairinterface.org/

NFV : recap

- ✓ Telecommunication infrastructure & services:

from dedicated distributed hardware elements

with built in intelligence.

to centralized software solutions to feed

a dumb, common, hardware infrastructure.

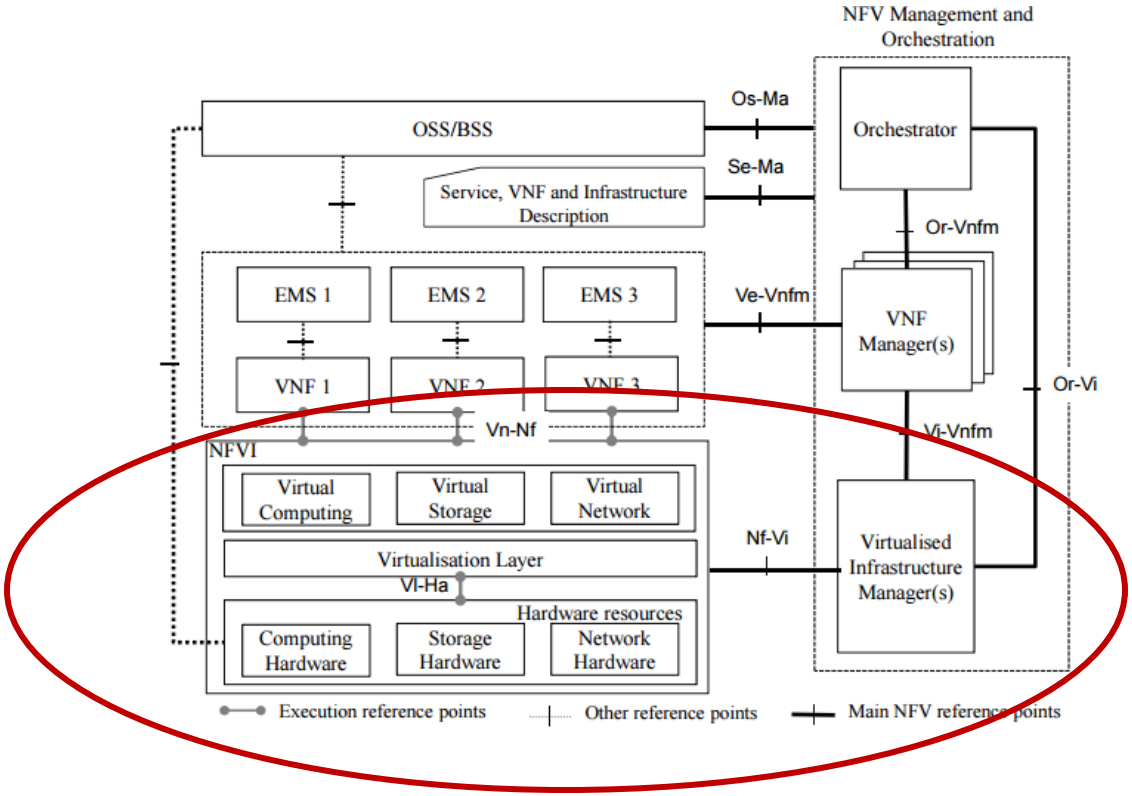
Open source networking - SDN

- ✓ New trend !
- ✓ Opportunity to innovate, collaborate with academia/industry.
- ✓ Impact on industry bottom line.
- ✓ Controllers:
  - ✓ ONOS- Java (http://onosproject.org/ 

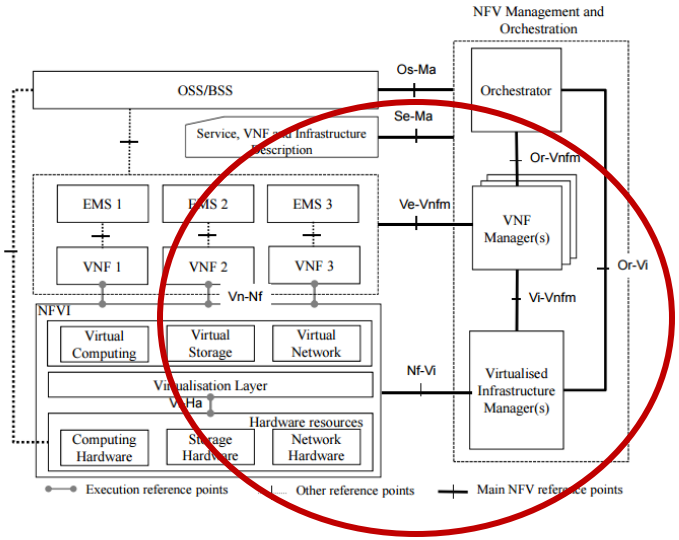
  - ✓ OpenDaylight - Java (http://www.opendaylight.org/)
  - ✓ Ryu – Python (https://osrg.github.io/ryu/)
  - ✓ + many others
- ✓ Testbeds:
  - ✓ Mininet - Python (http://mininet.org/) .

Open source networking - VIM

- ✓OpenStack (https://www.openstack.org/)
- ✓Apache CloudStack (https://cloudstack.apache.org/)
- ✓ + some other….



Open source networking– NFV projects



- ✓ Open NFV: https://www.opnfv.org/
- ✓ Open Source MANO: https://osm.etsi.org/
- ✓ Open Baton: http://openbaton.github.io/
- ✓ (Open O: https://www.open-o.org/)→ Open Network Automation Platform (https://www.onap.org/)
- ✓ CORD (E-CORD / M-CORD): http://opencord.org/

Note: OS community releases faster than Standardization

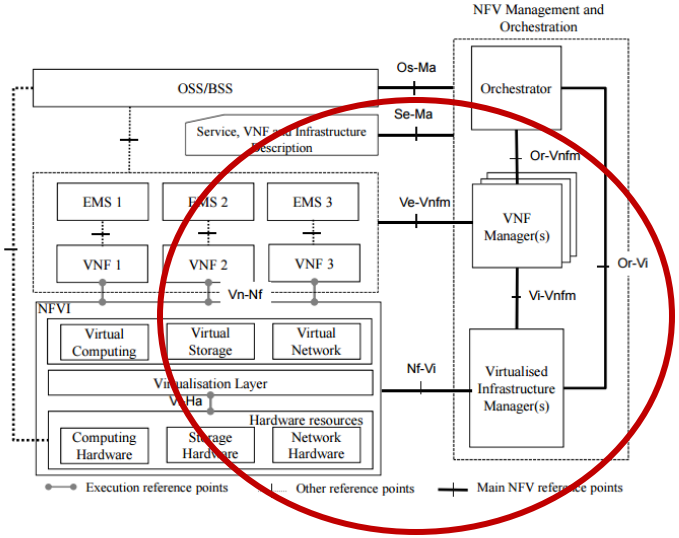
Open Source networking– NFV projects

- ✓ Common for NFV projects:
  - ✓ Partial adherence to standards (except OSM).
  - ✓ Open Stack as the reference VIM.
  - ✓ Support different SDN controllers
    - through VIM.
  - ✓ VNF programmability and orchestration interfaces
    - Proprietary (RESTful / other)
    - OASIS Topology and Orchestration Specification for Cloud Applications (TOSCA) https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=tosca#announcements
    - Reuse of multiple OS projects / components:

      -Django: https://www.djangoproject.com/

      -Ansible: https://www.ansible.com/

      …



CORD: an interesting case of OS NFV platform

- ✓ Central Office Re-architected as a DataCenter.

- ✓ CO. High (set-up + operational) costs:
  - buildings packed with hardware: real estate + supervision & maintenance + powering (!) + obsolescence of it all.

- ✓ ONLab (http://onlab.us/) proposal for a framework to ease building and managing scalable services based on the principle of *"anything-as-a-service"* (XaaS).

Images Source:
- https://www.wti.com/t-wti-site-visits-miami-911-central-office-tour.aspx
- http://www.levylaw.com/asbestos-telephone-exchanges/
- http://www.chinacheerwe.com/Solutions/FTTH-Solutions-From-Cheerwe-Telecom/

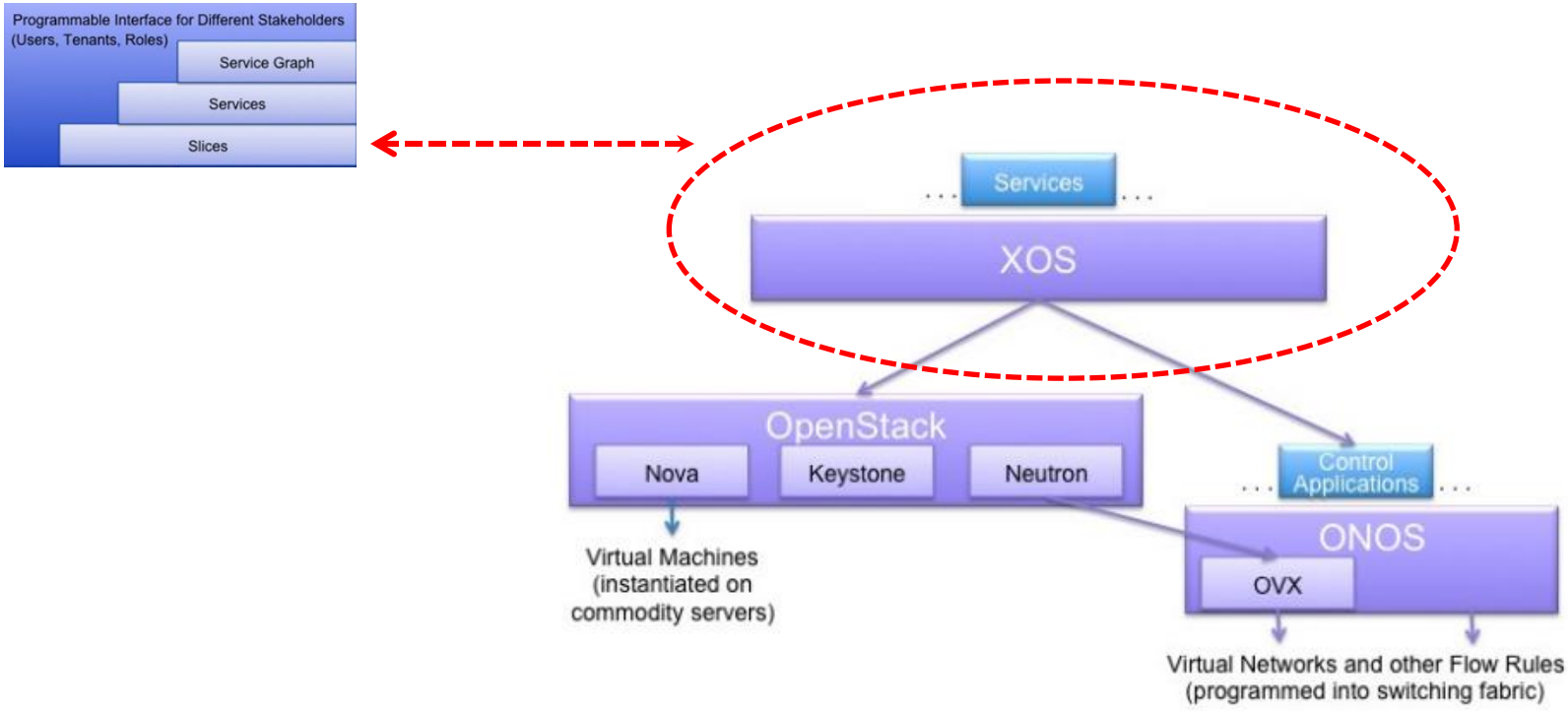
CORD: an interesting case of OS NFV platform

✓ Core components:

- Docker: container-based means to deploy and configure CORD (XOS, OpenStack, ONOS) as well as to deploy and interconnect services.
- XOS: framework to assemble and compose services. Unifies data plane services by OpenStack and Docker.
- OpenStack: core IaaS capability. Creates and provisions VMs and VNts.
- ONOS: network OS (SDN Controller). Hosts ctrl apps. implementing services and is responsible for virtual networking (overlay + underlay) within the network infrastructure.

CORD: an interesting case of OS NFV platform

Source:
http://onosproject.org/wp-content/uploads/2015/06/Technical-Whitepaper-XOS.pdf



- XOS: Extensible Cloud Operating System (http://xosproject.org/wp-content/uploads/2015/04/paper-xos-bigsys15.pdf)

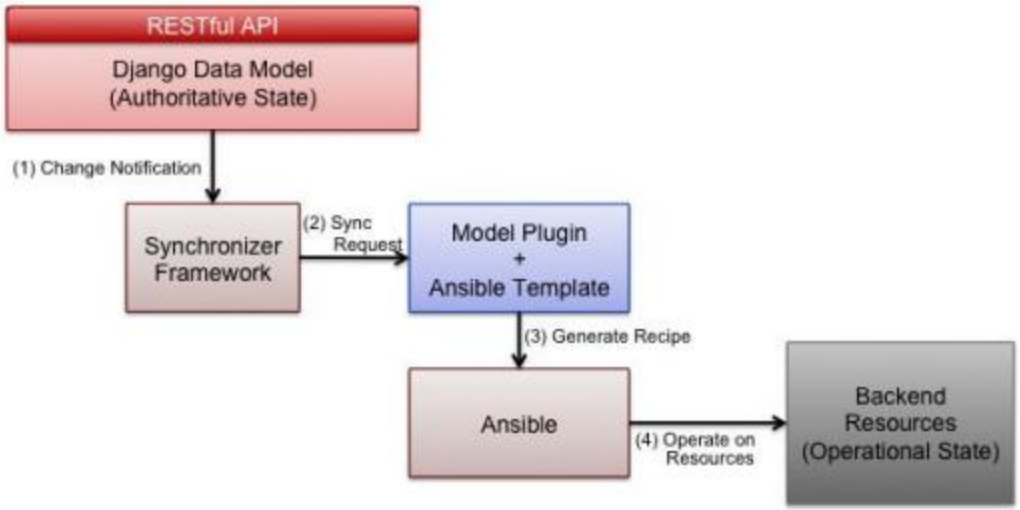
CORD: an interesting case of OS NFV platform

✓ XOS includes a language for writing service ctrl programs (policy statements) and a runtime system to apply them:

- Authoritative Data Model (Django-based).
- RESTful + TOSCA programmatic interfaces for policy specification.
- Synchronizer (Ansible-based) to keep the operational state correlated to the auth state.

Source:

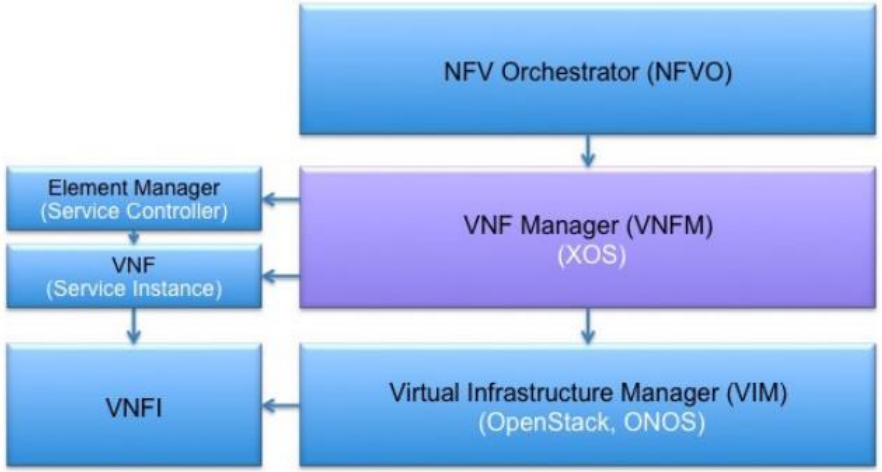
- http://opencord.org/wp-content/uploads/2016/03/Services-in-CORD.pdf



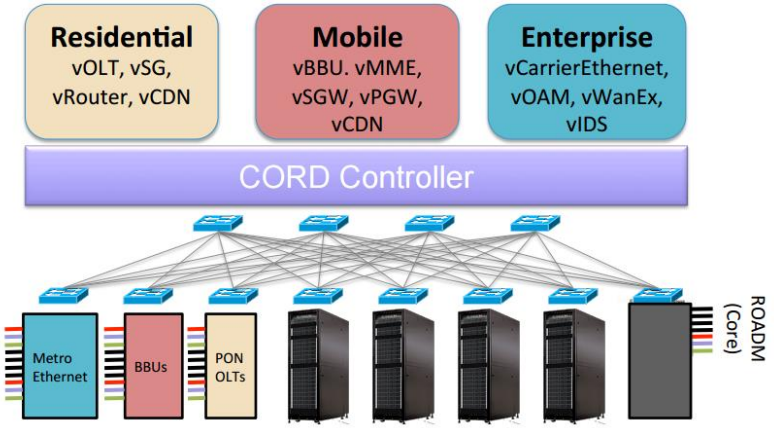
CORD: an interesting case of OS NFV platform

Source:

- http://onosproject.org/wp-content/uploads/2015/06/Technical-Whitepaper-XOS.pdf



✓ Specialization of CORD to serve different usage domains:



Source:

- https://wiki.opencord.org/display/CORD/CORD+Summit+--+July+29%2C+2016?preview=/1278537/1279414/Summit-Larry.pdf

Future ? 5G

- ✓ Mobile Networks : GSM (2G), GPRS(2.5G), UMTS (3G), LTE/A-LTE (4G) → 5G
- ✓ 5G Aims:
  - ✓ Massive increase in end-users (IoT, Vanets, …)
    - Increased capacity to the edge → Micro/Pico cells, massive MIMO, …
    - Multi-radio access technology → SDR



  - ✓ Massive reduction in delay.
    - The "tactile Internet".
      Human reaction time ~ 200 ms
      vs
      Latency to core ~ 100-400 ms

    - Enable new services. f.ex. Railway Virtual Coupling… !

Future ? 5G

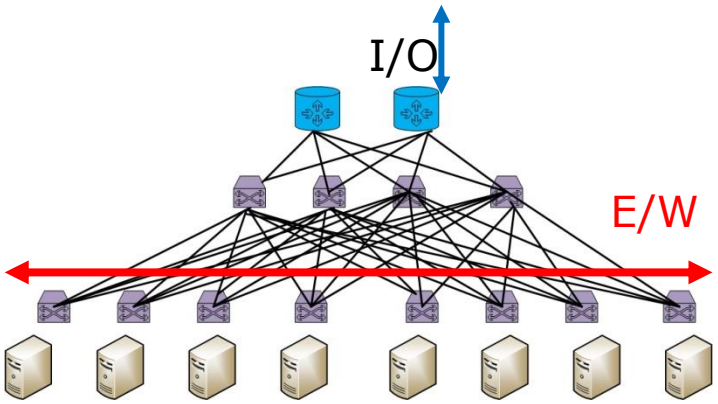
Impact on architectural needs:

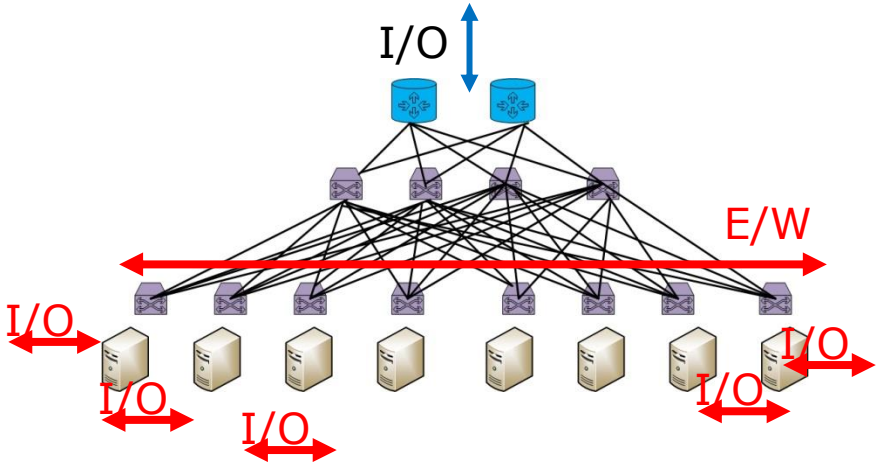
- Computing close to devices … "Fog computing"

  – Core/Backhaul Clouds

  vs

  – Access Clouds (I/O intensive in the leaves!)





Future ? Supporting Software

- ✓ Virtualization:
  - ✓ VMs vs Containers vs Unikernels … (increased efficiency)
- ✓ Automation & Coordination
- ✓ Interfaces for programmability.

Conclusion

- ✓ Telecommunication networks about to change:
  - ✓ Today: heavy (HW), highly static, dedicated deployments.
  - ✓ Tonight / tomorrow: lighter (SW), highly dynamic, highly multitenant.
- ✓ Evolution-pace very high!
  - ✓ Once you get used to a system/platform a new one is released.
  - ✓ Continuous update needed.
- ✓ New services around the corner….huge impact in telecommunication industry (roles, players, etc).
- ✓ Network engineers?
  - ✓ Increasingly in-depth software competences.
  - ✓ Still nt-understanding is fundamental…

Redes de Datos

De entes físicos a procesos software en entornos virtuales

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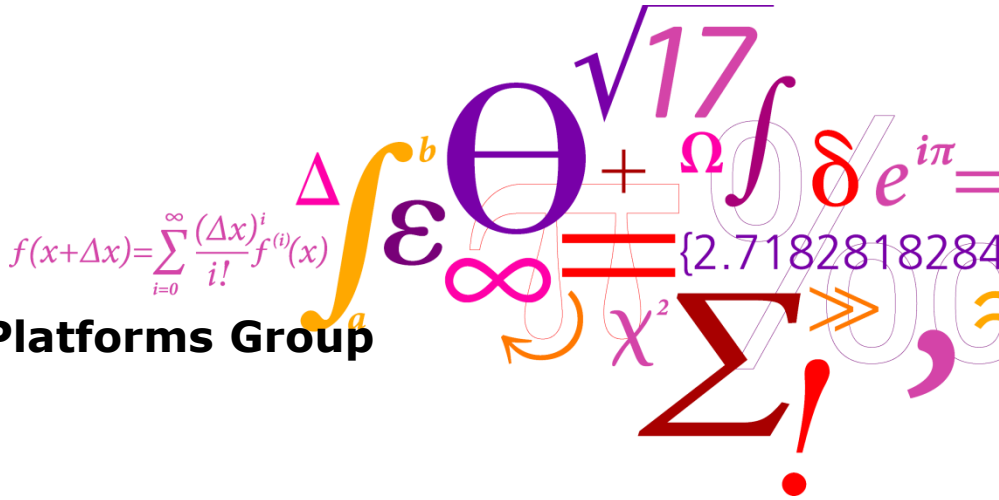

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