



*Keynote*

# **NFV & SDN innovations for 5G and Telco business**

**Gino Carrozzo**  
*Deputy Head of R&D*  
*Nextworks, Italy*

6<sup>th</sup> Int'l Conference on Networks ICN 2017  
SOFTNETWORKING2017,  
Apr 23-27, 2017 Venice, Italy



# Drivers for innovation in ICT and networks

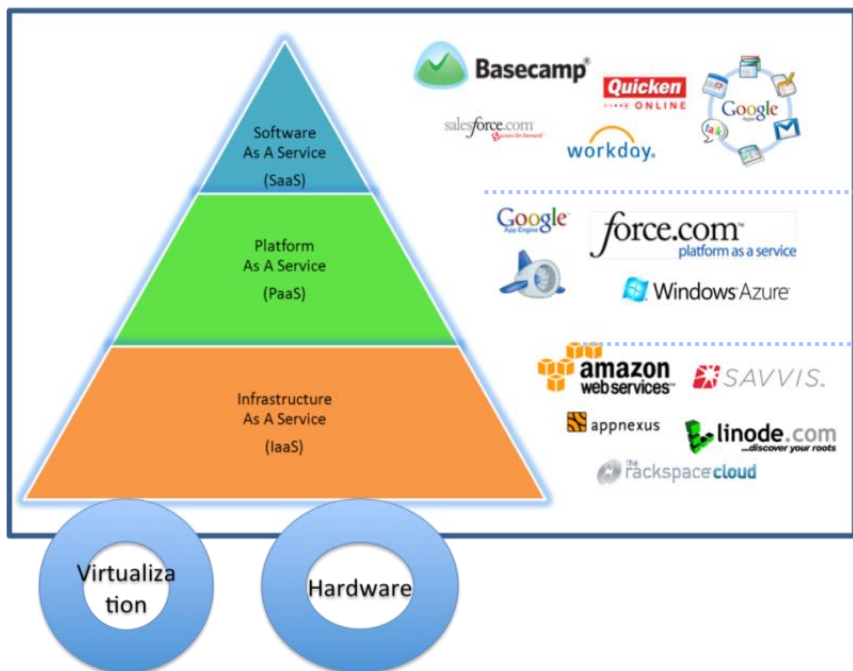
- The Data Centers and the PoPs are the focal point of this transformation
  - Self-service provisioning of virtual private network infrastructures & services for the customers
- High elasticity to scale up and down (virtualized) resources, while optimizing performance
- High service availability and disaster recovery
- Need for shorter time to market for new network functions/services
  - E.g. for DevOps

## DevOps cycle



# Drivers for innovation in ICT and networks (2)

- Telco market is rapidly moving towards an **Everything-as-a-Service model**, solidly sustained by
  - Virtualization & softwarization of traditionally in-the-box network functions (Network Functions Virtualization – NFV)
  - Deep network programmability tools/technologies
  - Advanced Infrastructure as a Service platforms and orchestration tools

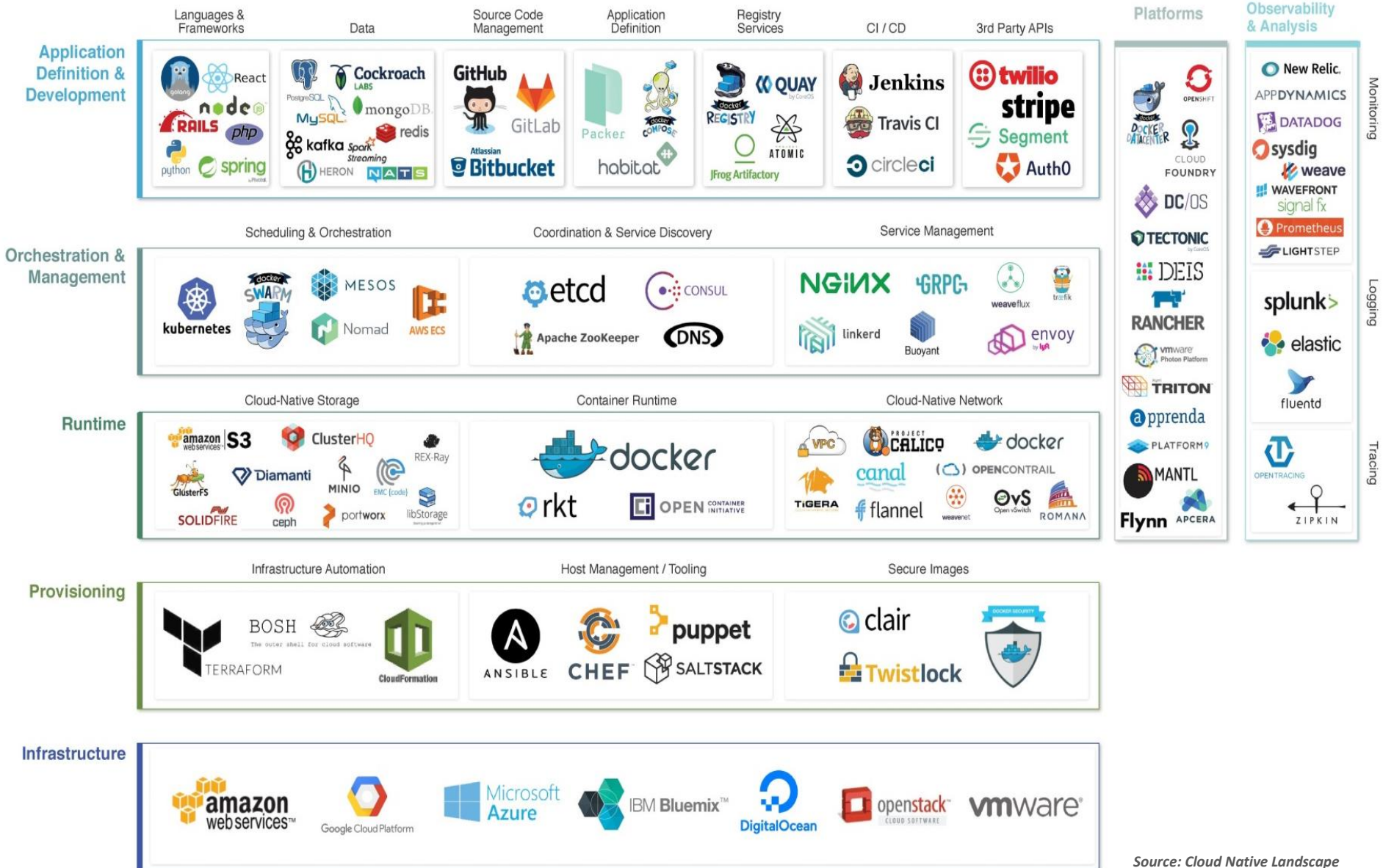


**SaaS:** Email, calendars, DMS, CRM, etc.

**PaaS:** OS, DBMS, LAMP/WAMP [virtual] servers, etc.

**IaaS:** Enterprise infrastructure, Cloud hosting, Virtual Data Centers, etc.

# In a complex landscape of technologies and tools



Source: Cloud Native Landscape

# Under the umbrella of today's major focus: the 5G

*"5G won't just be a bit faster, a bit higher capacity, or a linear progression from what we know today. The change will not be incremental, but exponential,"*

**Neelie Kroes**, EU's Digital Agenda  
Commissioner, February 2014

*"5G is ...shorthand for expanding capability for anywhere, anytime, anyhow connectivity for any application, or the network that optimises itself for you",*

**Marcus Weldon**, Corp. CTO and President of  
Bell Labs

- Europe, the United States, Japan, China, South Korea and the EU are deeply involved in 5G development towards 2020
- Europe has set aside €700 million for R&D on 5G through the 5G Public-Private Partnership
  - **17 5G PPP Phase1 projects** are currently running to develop the 5G foundations for
    - Use cases, Architecture, Radio spectrum, mmWaves and Software Defined Radio
    - Management and Orchestration through SDN/NFV technologies
    - Cognitive and autonomic network management
  - A similar amount of **new 5G PPP Phase2 projects about to start** (June-2017)
  - Nextworks is deeply involved in this R&D program:
    - 2 5GPPP Phase 1 projects, 5 new Phase 2 projects ready to start, private activities on NFV MANO

# 5 reasons for excitement on 5G – the verticals



**#1. The next Winter Olympic host city of Pyeongchang could host the first-ever 5G Olympics in 2018.**



**MWC 2014 participants dreaming up amazing new uses for 5G networks**

*The Washington Post*



**#5. Green 5G networks and devices**



**#2. The "Internet of Everything"**



**#3. driverless cars with infotainment, comms, traffic navigation and device syncing**



**#4. Next-gen mobile healthcare devices**

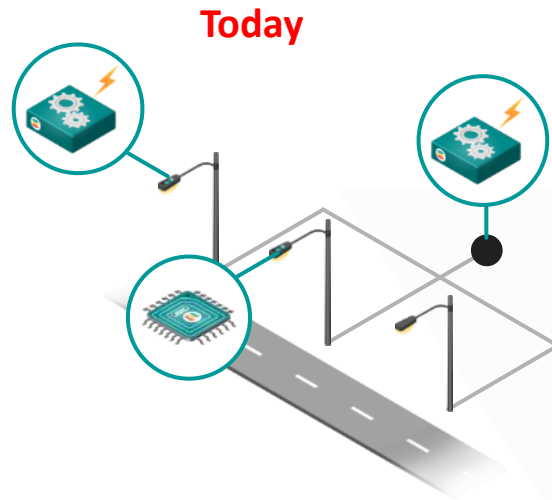
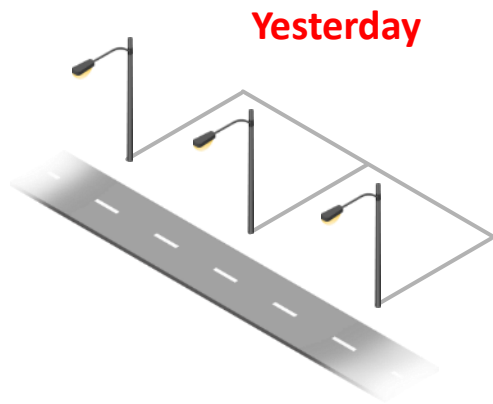
[http://www.washingtonpost.com/blogs/innovations/wp/2014/02/27/five-reasons-to-get-excited-about-5g-networks/?tid=pm\\_national\\_pop](http://www.washingtonpost.com/blogs/innovations/wp/2014/02/27/five-reasons-to-get-excited-about-5g-networks/?tid=pm_national_pop)

# Example: Smart Street Lighting

STANDARD LIGHTING

SMART STREET LIGHTING

5G SMART CITIES



- Individual on/off using photocells

- Remote on/off
- Segment controls
- Remote management and control (dimming)

- New city services like pollution sensors, traffic cameras, parking management, signage, EV charging, emergency response, etc.
- Integration with rest of grid

# Example: Asset Management with augmented reality





# New service capabilities in 5G

- Three different types of traffic profiles
  - high throughput for e.g. video services
  - low energy for e.g. long-living sensors
  - low latency for mission critical services

1000 TIMES



20 BILLION  
HUMAN-ORIENTED TERMINAL



1 TRILLION



- Digitalization of **vertical markets**

- automotive, transportation, manufacturing, banking, finance, insurance, food and agriculture, city management, energy, utilities, real estate, retail....

90%



<5MS LATENCY



99.999%



Source: 5G PPP

- **Sustainable and scalable technology** to handle

- growth in number of terminal devices and traffic (at a 50-60% CAGR)
- heterogeneous network layouts
- without causing dramatic increase of power consumption and management complexity within networks

# A Paradigm Shift: the agile Software Network for 5G



## Network Programmability (SDN)

Decouple network equipments control and data planes

Service Agility

CAPEX & OPEX reductions

Network Programmability

Service Personalization

Software network control functions

Software defined network (SDN) Controllers

Data plane network elements

## Next Generation Operations Support Systems

## Network Cloudification (NFV)

Deploy software network functions in virtualized COTS infrastructure

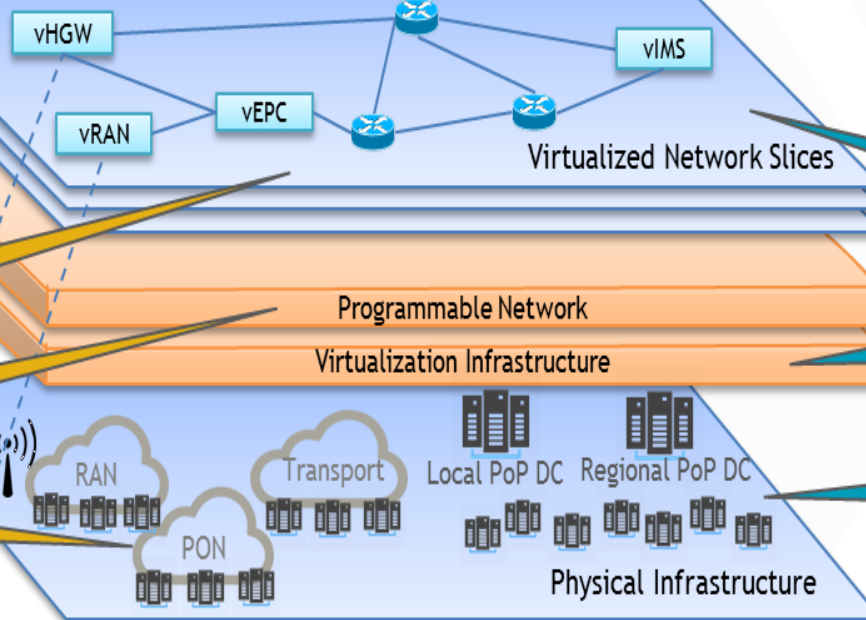
Service Agility

CAPEX & OPEX reductions

Software network functions (VNFs)

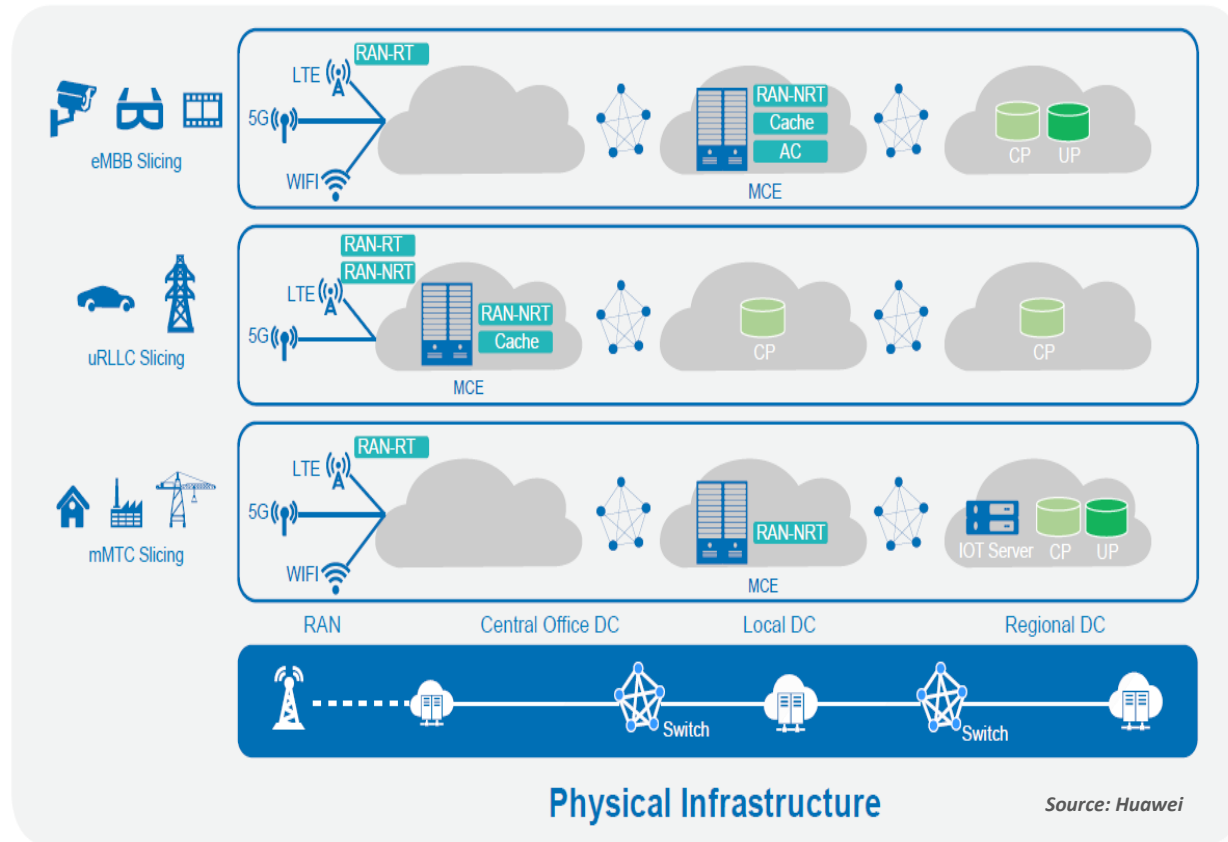
Hypervisors

COTS infrastructure



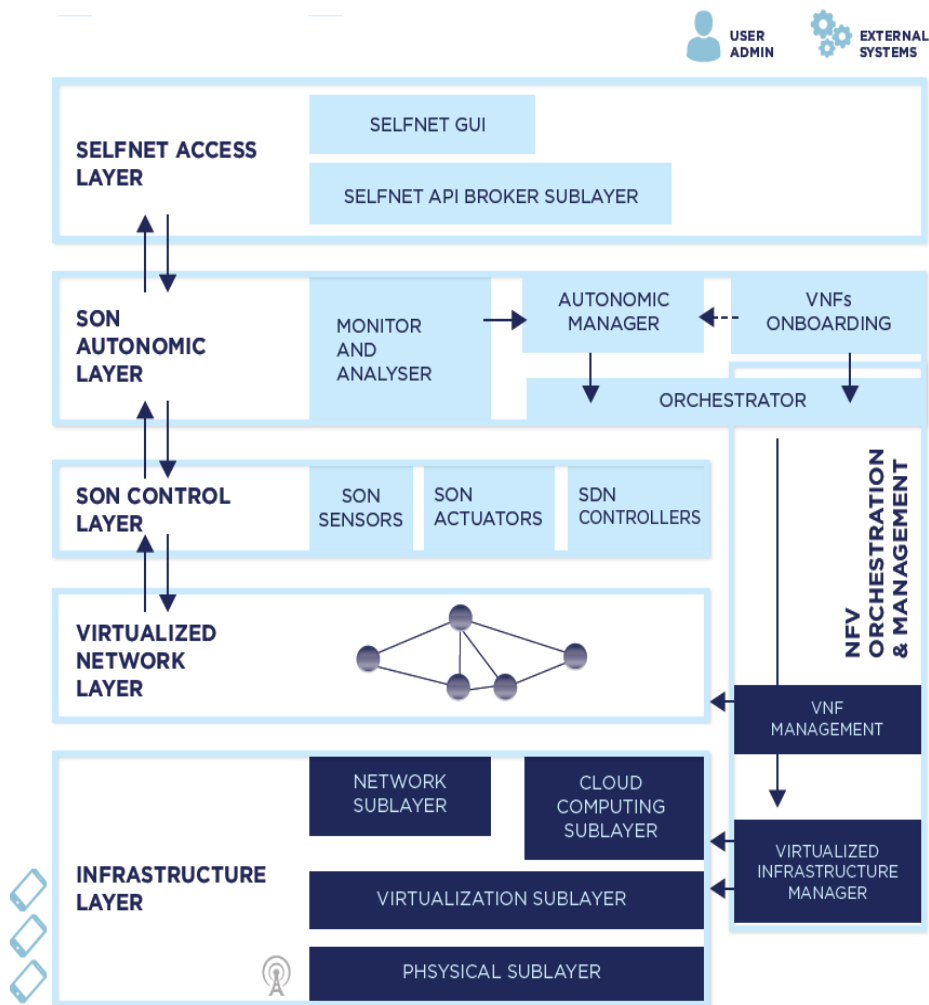
# 5G Network Slicing through SDN/NFV

- Slicing is a way to provide fully or partly, logically and/or physically isolated sub-networks on top of a shared infrastructure [see NGNM]
  - Set of network (and non-network) functions and resources (both phy and virt)
  - A complete instantiated logical network fulfilling the characteristics of the Service Instance(s)
  - Autonomous control loop (orchestrators and controller chain) in the slice
- Current 3GPP networks do not support a notion of slicing
- Virtualization, SDN and NFV are key enablers of Network Slicing



eMBB – Enhanced Mobile Broadband  
 uRLLC – Ultra-reliable and Low-latency Communications  
 mMTC - Massive Machine Type Communications

# SDN/NFV for autonomic network management in 5G



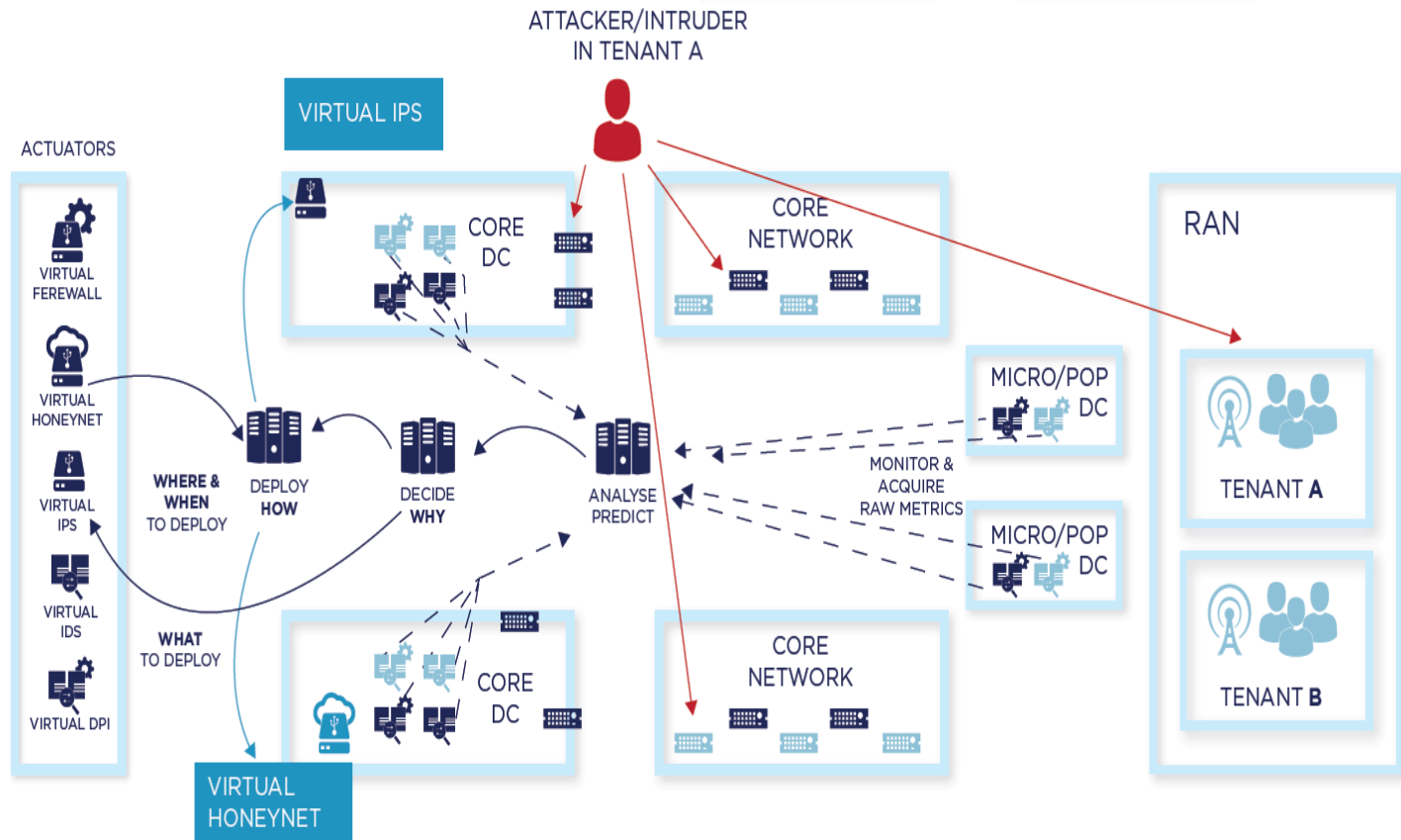
- Need for a framework for automated network service provisioning and monitoring, capable of
- **Automated deployment** of network management tools and functions
- **Automated network monitoring**
- **Autonomic network maintenance** via high-level tactical measures
- **Autonomic corrective and preventive actions** to mitigate existing or potential network problems
- **Virtualized tools and mechanisms** to protect the network from various threats
- This is SELFNET:



<https://selfnet-5g.eu>

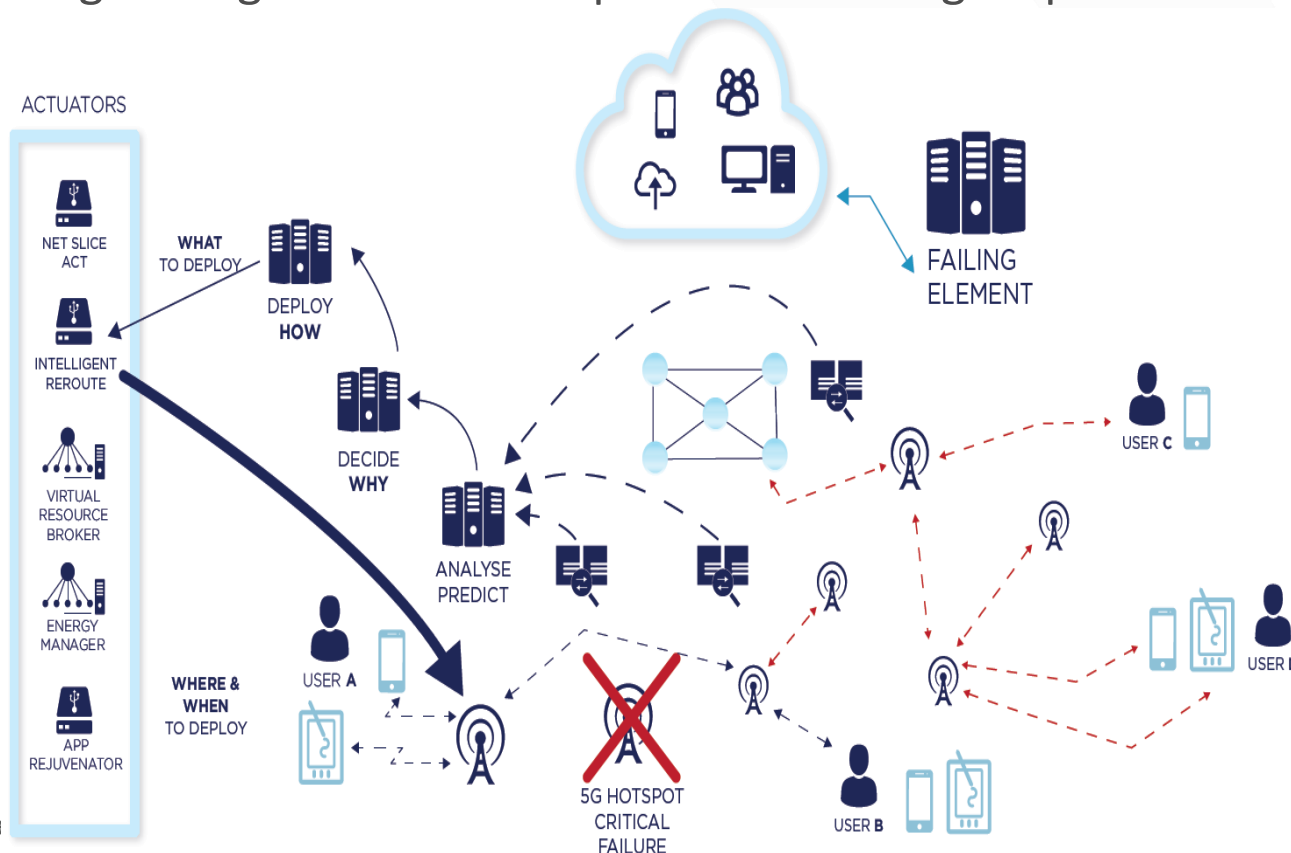
# Example use case: self-protection in 5G

- **Goal** Detect and mitigate effects of cyber-attacks and restore 5G network traffic to a steady state of security
- **How** VNFs (virtual Traffic monitor/DPI, virtual Threat Management System, virtual honeynets, virtual Intrusion Protection System) deployed and chained at different locations of the network (e.g., at the mobile access, PoP or in the core)



# Example use case: self-healing in 5G

- **Goal** Detect and predict common failures/malfunctioning in 5G network infrastructure (hw/sw failures, infrastructure/operation vulnerabilities or power supply interruptions) to apply reactive or preventive recovery
- **How** Self-healing analyzer to infer Health of Network metrics coupled with self-healing diagnosis intelligence to derive potential problems. Decision making intelligence to realize proactive healing responses.

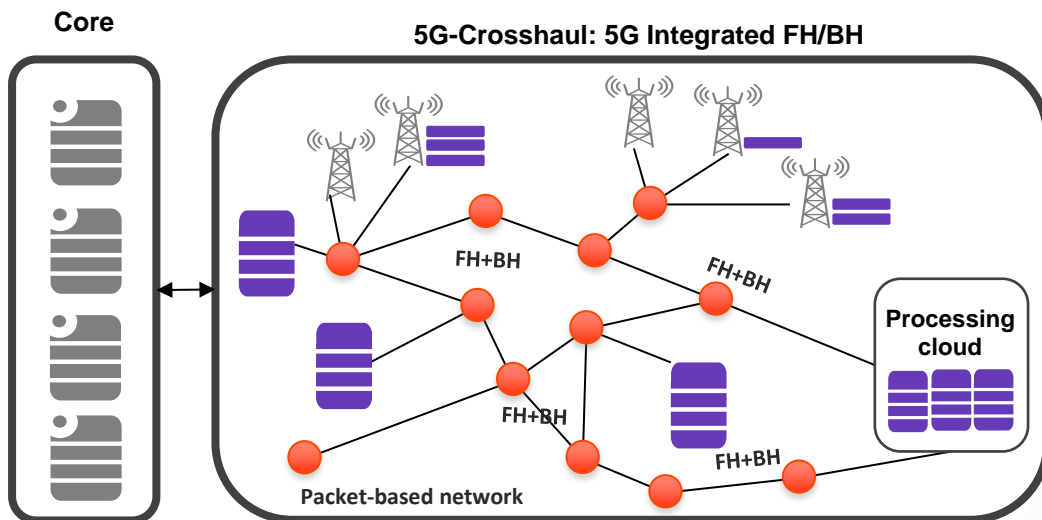
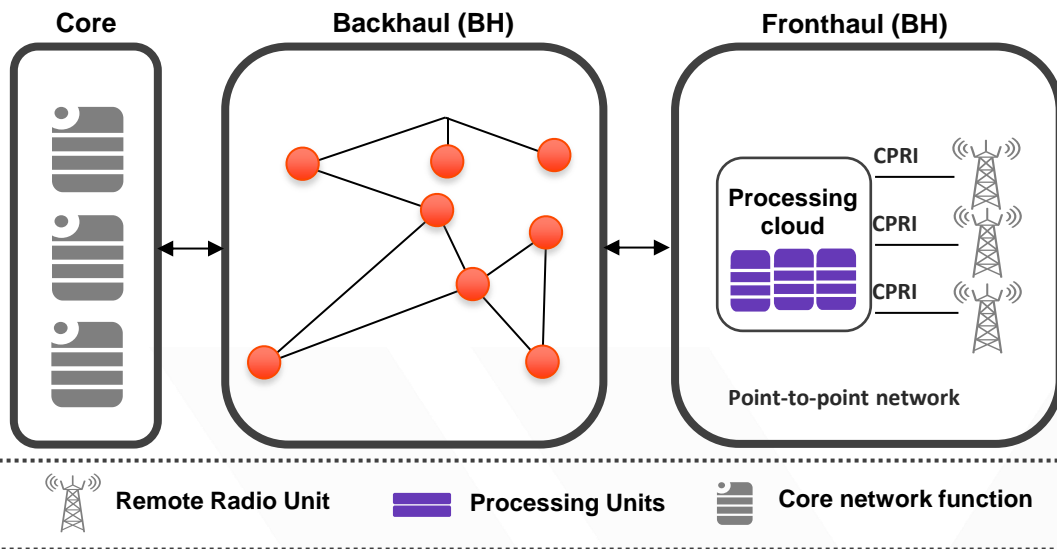


# SDN/NFV technologies for the 5G crosshaul

## Today's C-RAN Mobile Transport Network

CPRI transports IQ data via point-to-point optical links in a fronthaul (FH) network.

- BW provisioning is independent on user's load
- No path diversity and multi-tenancy
- Separated management platforms (FH - BH)
- C-RAN Functional split and placement is fixed and static



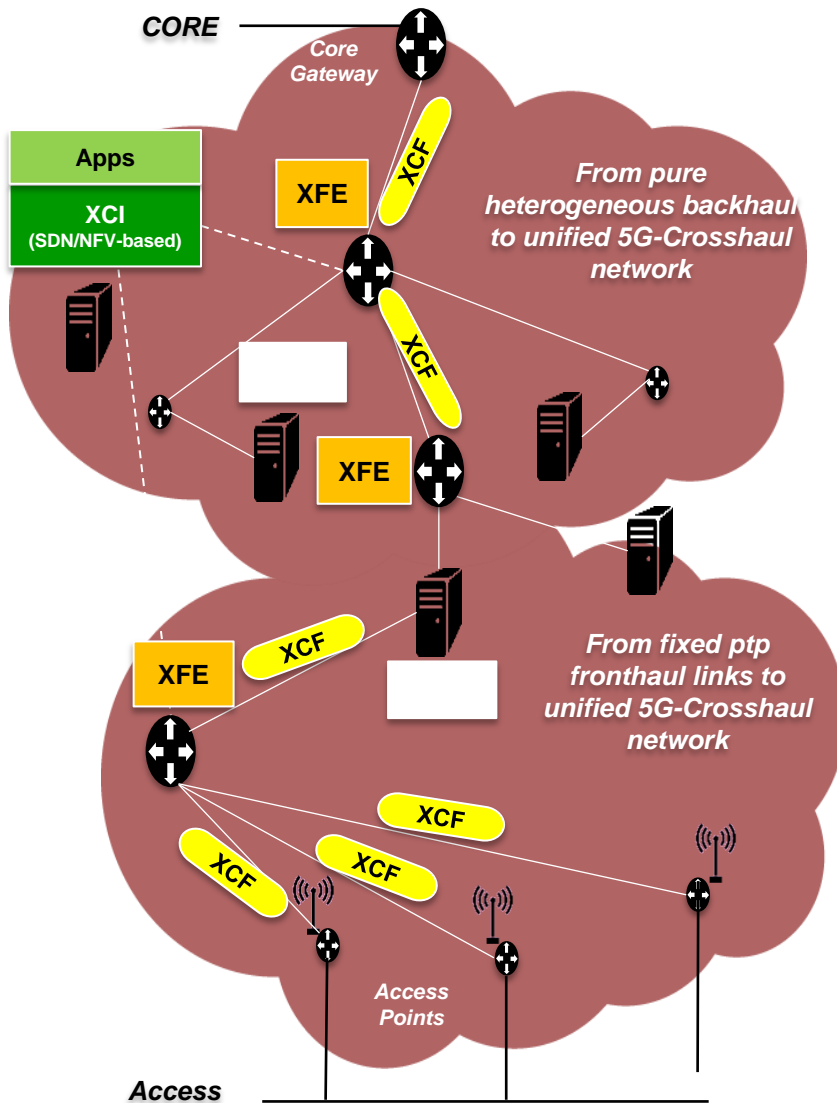
## 5G-Crosshaul: 5G Mobile Transport Network

5G C-RAN is being transformed to a packet-based network (NGFI/IEEE/CPRI).

FH and BH will converge to an integrated transport network (Crosshaul):

- Efficient BW usage dependent on user's load
- Enables path diversity – Packet-based Routing with higher fault tolerance/Load balancing
- Unified management platform (FH + BH)
- C-RAN Functional split and placement
  - Variable – Support of different functional splits
  - Dynamic – NFV-based 5G networks

# SDN/NFV technologies for the 5G crosshaul (2)



- Need for **converged Fronthaul and Backhaul** under common SDN/NFV-based control, capable of supporting new 5G RAN architectures (vRAN) and performance requirements

- This is 5G Crosshaul: **5G X Crosshaul**

<http://5g-crosshaul.eu/>

- Main building blocks

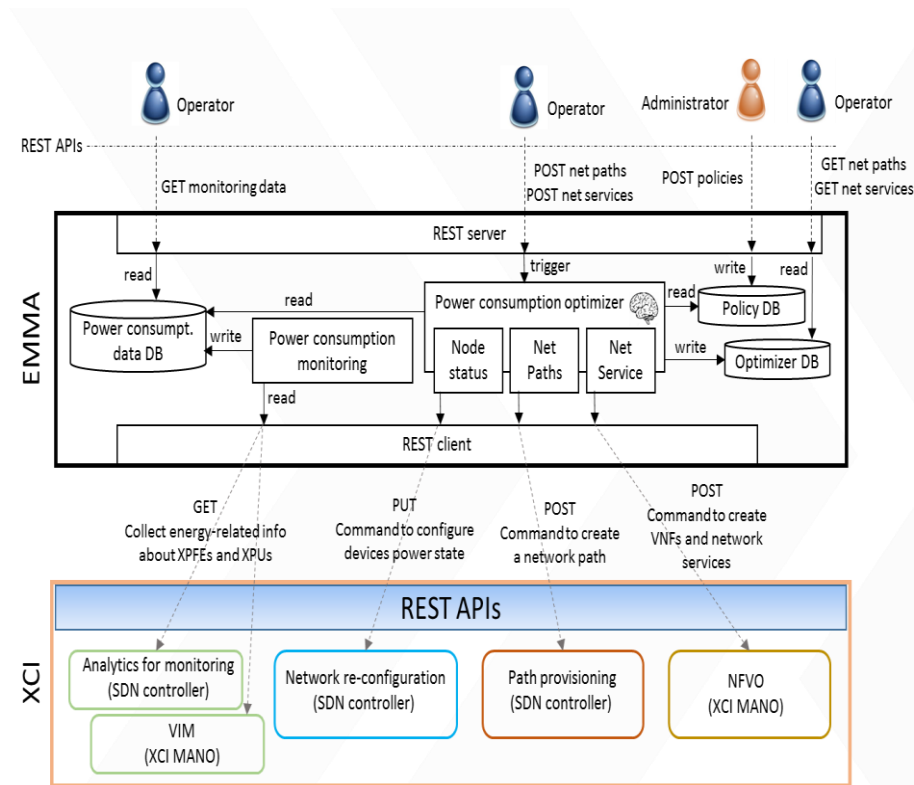
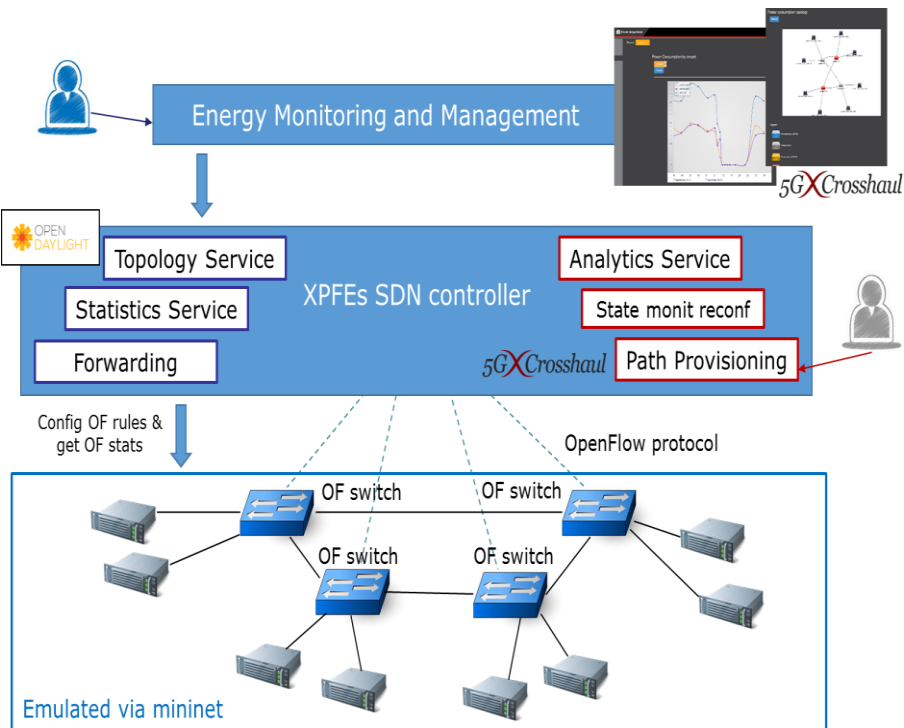
- **XCF – Crosshaul Common Frame** capable of transporting the mixture of various Fronthaul and backhaul traffic
- **XFE – Crosshaul Forwarding Element** for forwarding the Crosshaul traffic in the XCF format under the XCI control
- **XPU – Crosshaul Processing Unit** for executing virtualized network functions and/or centralized access protocol functions (vRAN)
- **XCI – Crosshaul Control Infrastructure** that is SDN-based and NFV-enabled for executing the orchestrator's resource allocation decisions
- **Novel Apps** on top to achieve certain KPIs or services for e.g. energy management, VNF placement, etc.



# Exemplary novel Network App: EMMA

- **EMMA - Energy Management and Monitoring Application**

- Compute power consumption dynamically based on traffic statistics (analytical model)
- Dynamically adjust network node power states (active/sleep) based on active traffic flows

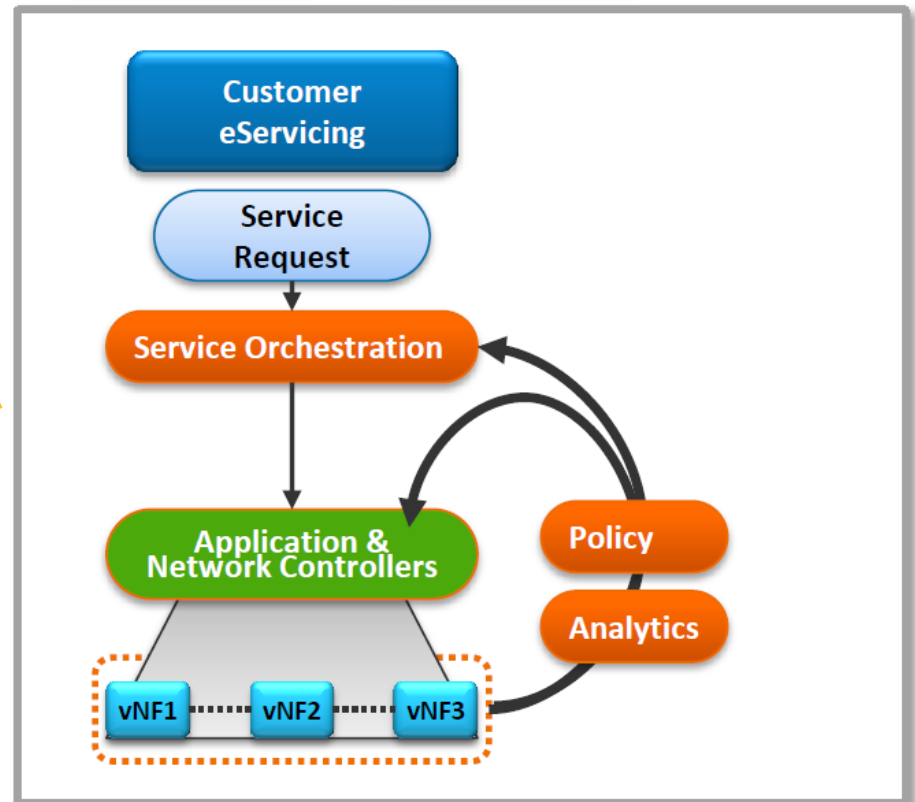
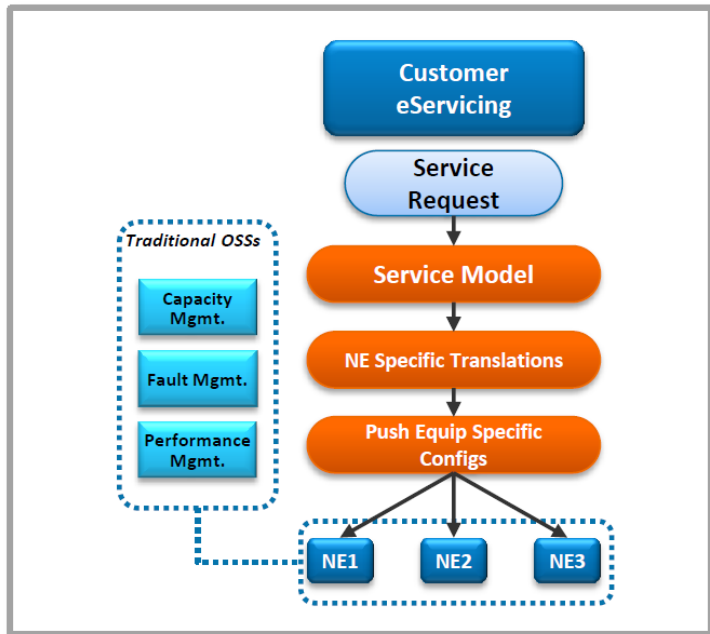


# The Telco Service Model is deeply changing

- Service Elements configured independently by different departments
- Capacity Mgmt, Fault Mgt, Performance Mgt outside the network



- Service is auto-provisioned through central orchestration
- Network is the DB for Billing, Ops, Care, etc.
- Network provides state and analytics also for Verticals



# Some key research challenges

- **Multi-technology abstraction**
  - Technologies evolve to offer more and more throughput
  - Network nodes evolve and incorporate multiple functions of non-network domains (e.g. computing and storage)
  - 5G scale is incredibly larger than the one in our current workspace. I.e. the abstraction model for 5G terminals, small cell, network nodes can be very complex
- **Multi-tenancy across federated domains (see also AT&T Network 3.0 – Indigo)**
  - The coordination of control functions across distributed control instances is still a problem
  - High volumes of unstructured information and control data from heterogeneous devices call for distributed data sharing mechanisms inspired to mem-caches/NoSQL, etc., more than traditional control plane protocols for routing and signaling
    - AT&T Indigo is aiming at a community platform for the Network 3.0 which will enable dynamic, on-demand combinations of data to be sourced from multiple entities and merged into shared communities to derive insights in a highly secure environment

## Some key research challenges (2)

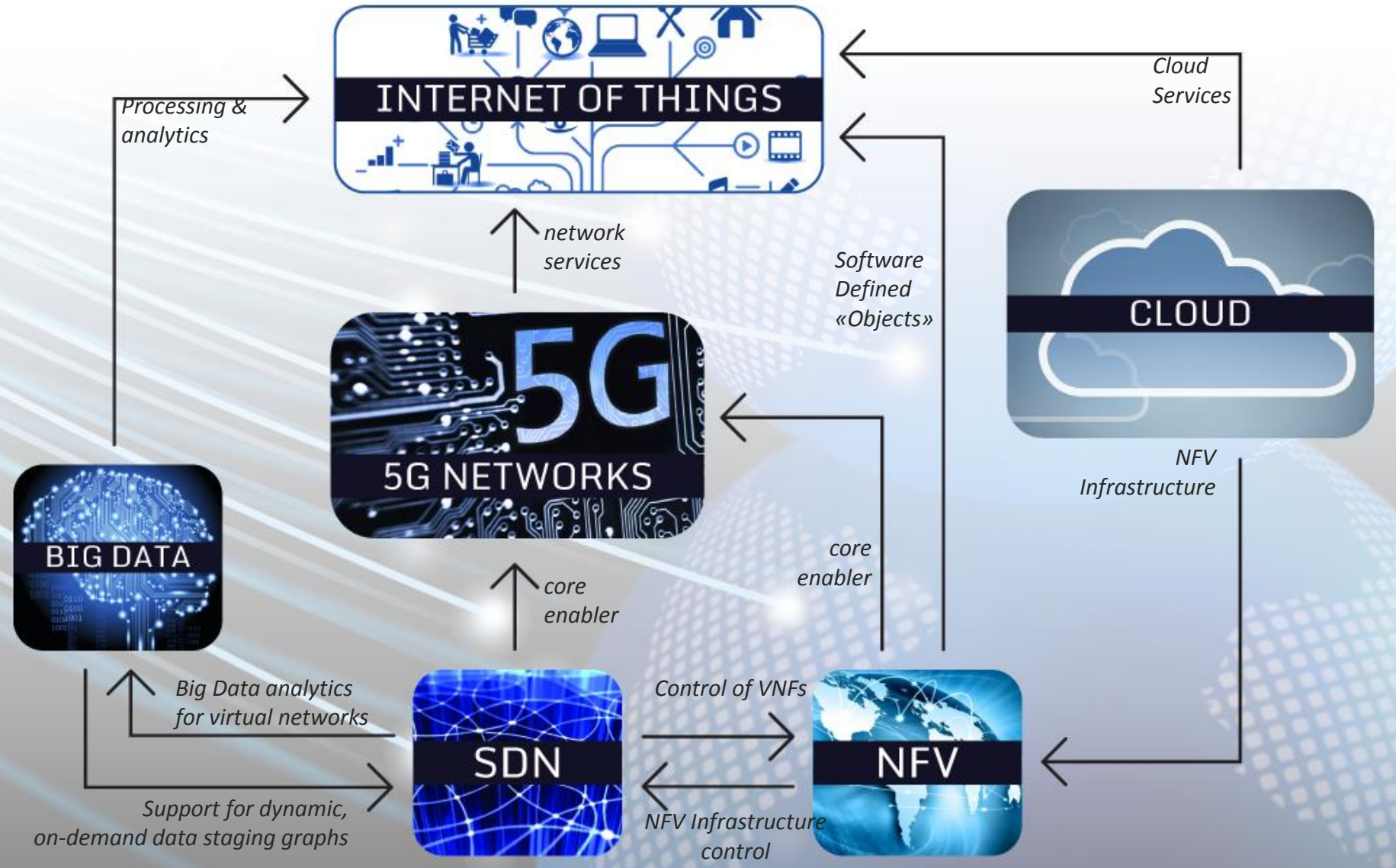
- On the user-side, **Big Data applications** are coming with new challenges for complex virtual networks that may require **"multi-stage" operation**
  - network to improve performance during big data uploads (petabyte-scale) lowering the job execution time from weeks to days
  - network to sustain big amounts of batch computational load at specific times
- Many service features need to be defined in a complete, more coherent and usable way to integrate OTT services with the **Northbound Interface of the Softwarized Networks**; e.g.
  - Common authentication credentials and procedures
  - Accounting of services used
  - Connectors to charging and billing (either besides in the Management Plane, or as parallel apps on a lower recursion layer)
  - Reliability procedures to make the APIs dependable
  - Exchange of monitoring and performance information
  - ... anything else needed to support the implementation of SLAs across the API

## Some key research challenges (3)

- **Test 5G Infrastructures at large scale** for validation are very much needed
  - Interconnected labs for truly large scale experimentation, with real backbone in between
  - Multiple stakeholders (industry, research infrastructure owners) for the wider geographical coverage across continents
  - More rich set and more dense deployment of heterogeneous technologies, control solution, and Virtual Network Functions
  - Consolidate more valuable results with a large impact group
- *<....add your challenges here>*

# Final words...

Telecom & IT getting integrated towards a common high capacity ubiquitous infrastructure





# Thank you !!

**Gino Carrozzo**  
Deputy Head of R&D  
[g.carrozzo@nextworks.it](mailto:g.carrozzo@nextworks.it)



*This work was partially funded by the  
European Commission Horizon 2020 5G-PPP  
Programme under Grant Agreement number  
H2020-ICT-2014-2/671672 - SELFNET*

**Nextworks s.r.l.**  
via Livornese, 1027  
56122 S. Piero a Grado, Pisa - ITALY