

Telefonica



Control Plane for High Capacity Networks

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***V International Workshop
on Trends in Optical Technologies***
Towards Terabit per Second Optical Networking

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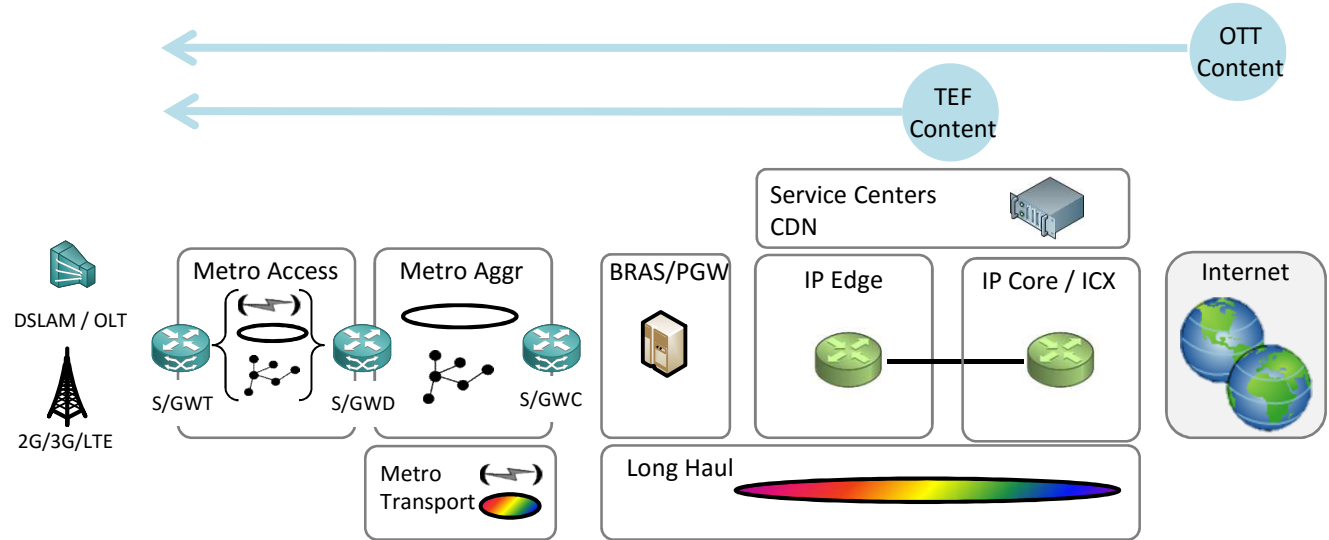
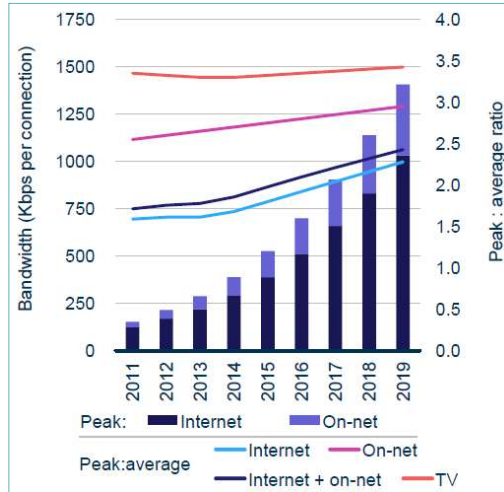
01



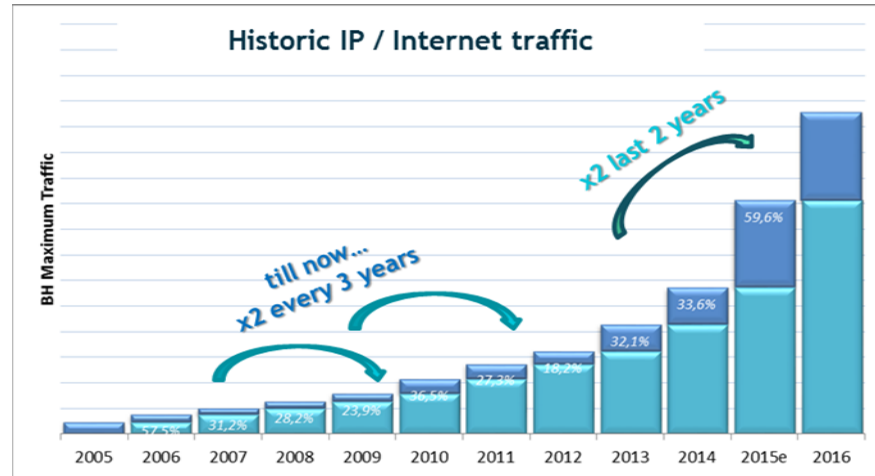
Motivations for
Network
Programmability

Data traffic pressure

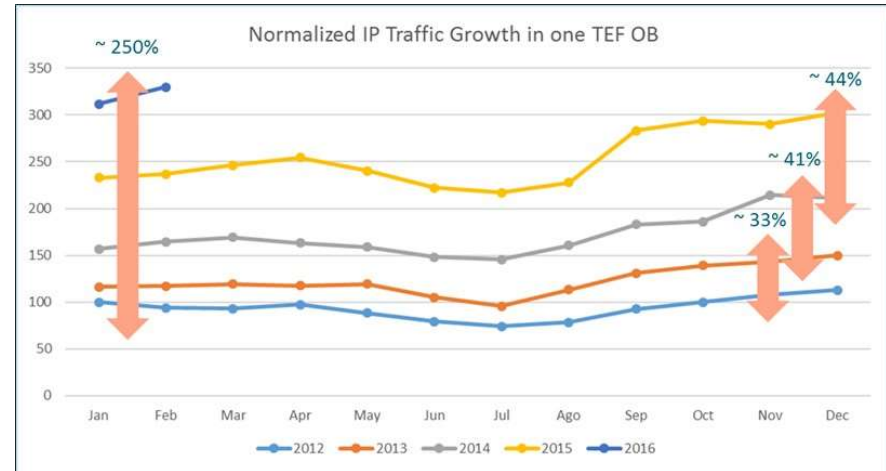
Bandwidth by peak and average ratio [Analysys Mason]



BH

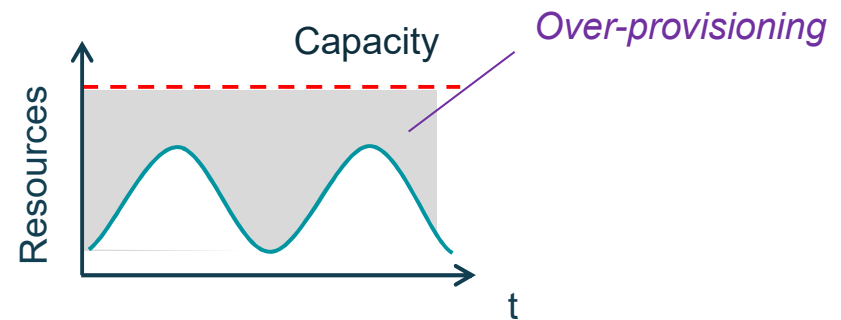
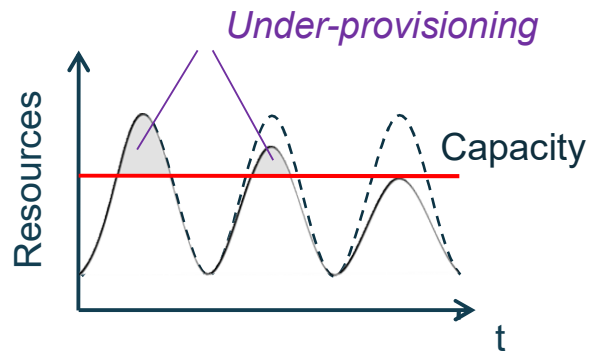


Interconnection

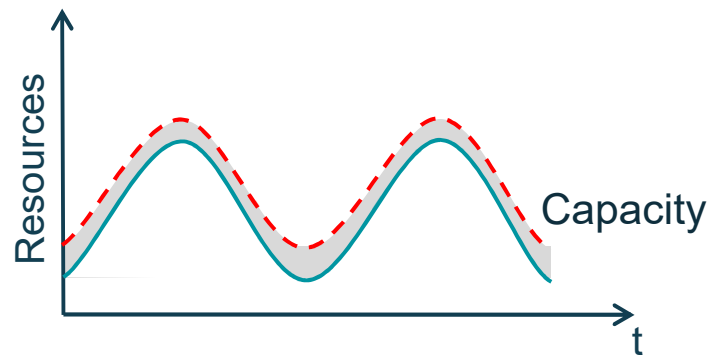


Looking for Elasticity

- Traditional network dimensioning yields to this situations:



- Ideally, the network must dynamically be adapted to the end users demands



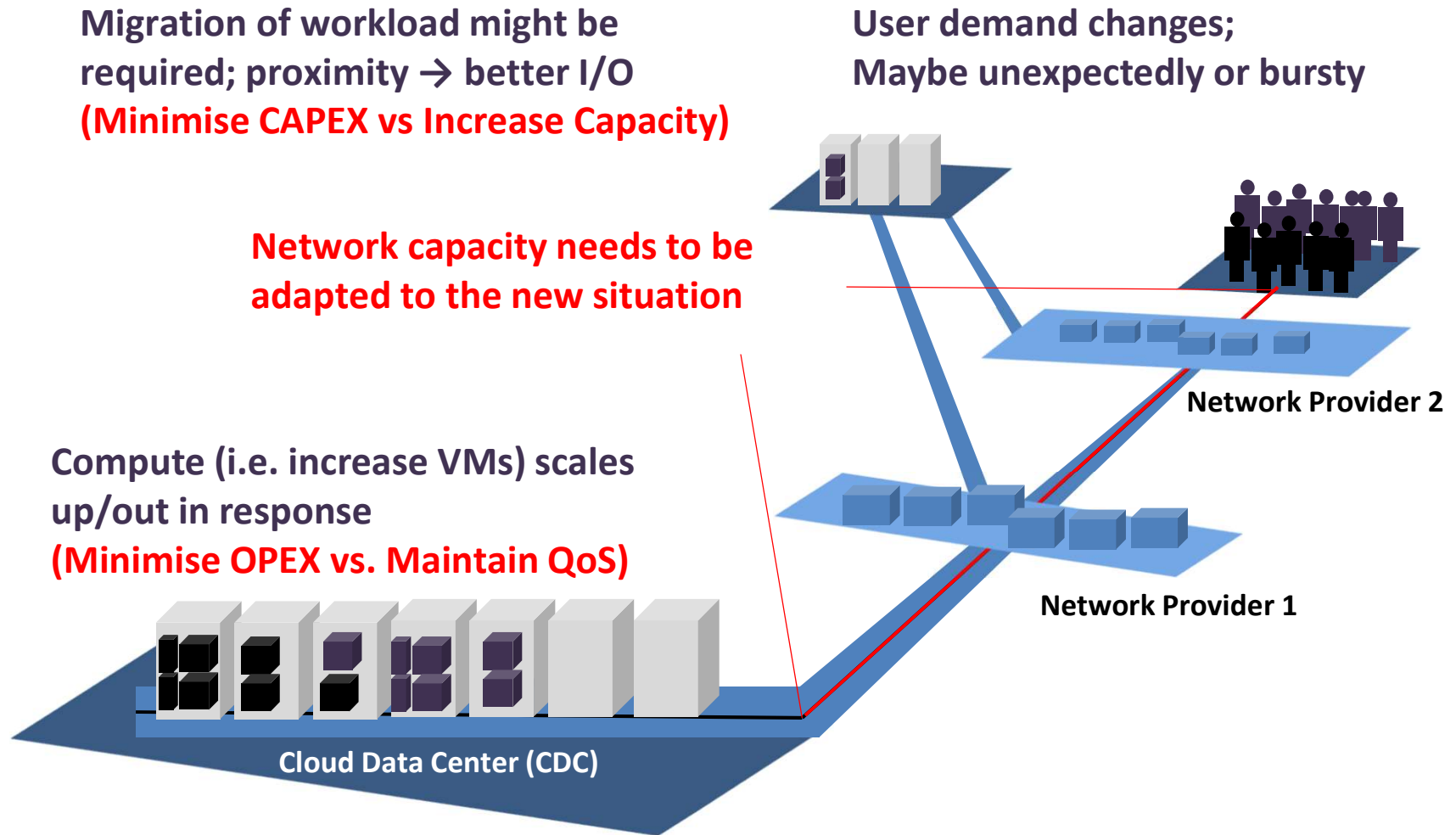
Telco Cloud

Legacy Carrier Networks were not designed to cope with customized service creation and delivery with very short lead times

Migration of workload might be required; proximity → better I/O
(Minimise CAPEX vs Increase Capacity)

Network capacity needs to be adapted to the new situation

Compute (i.e. increase VMs) scales up/out in response
(Minimise OPEX vs. Maintain QoS)



User demand changes;
Maybe unexpectedly or bursty

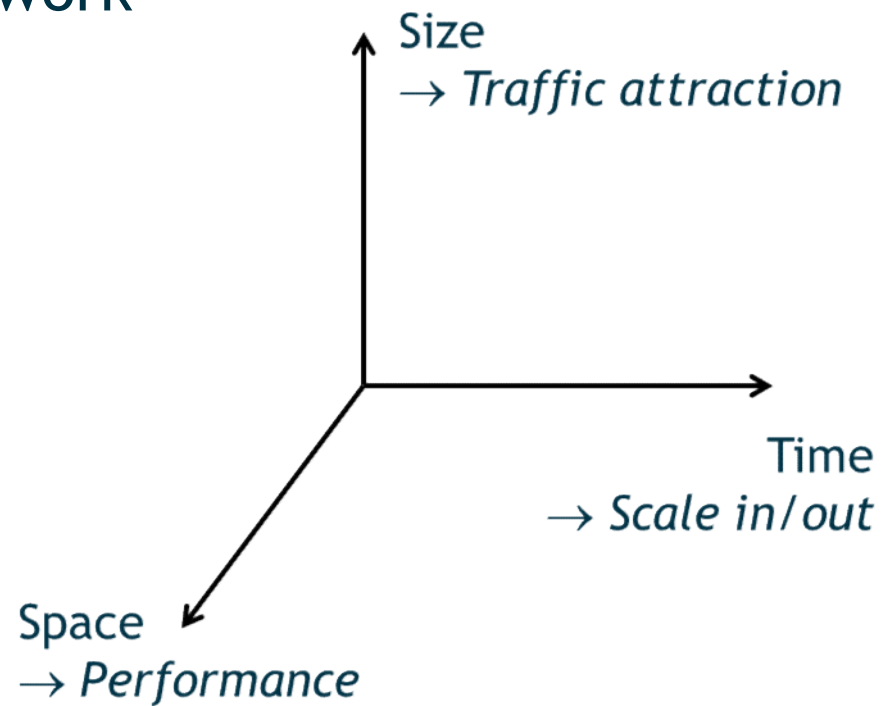
Network Provider 2

Network Provider 1

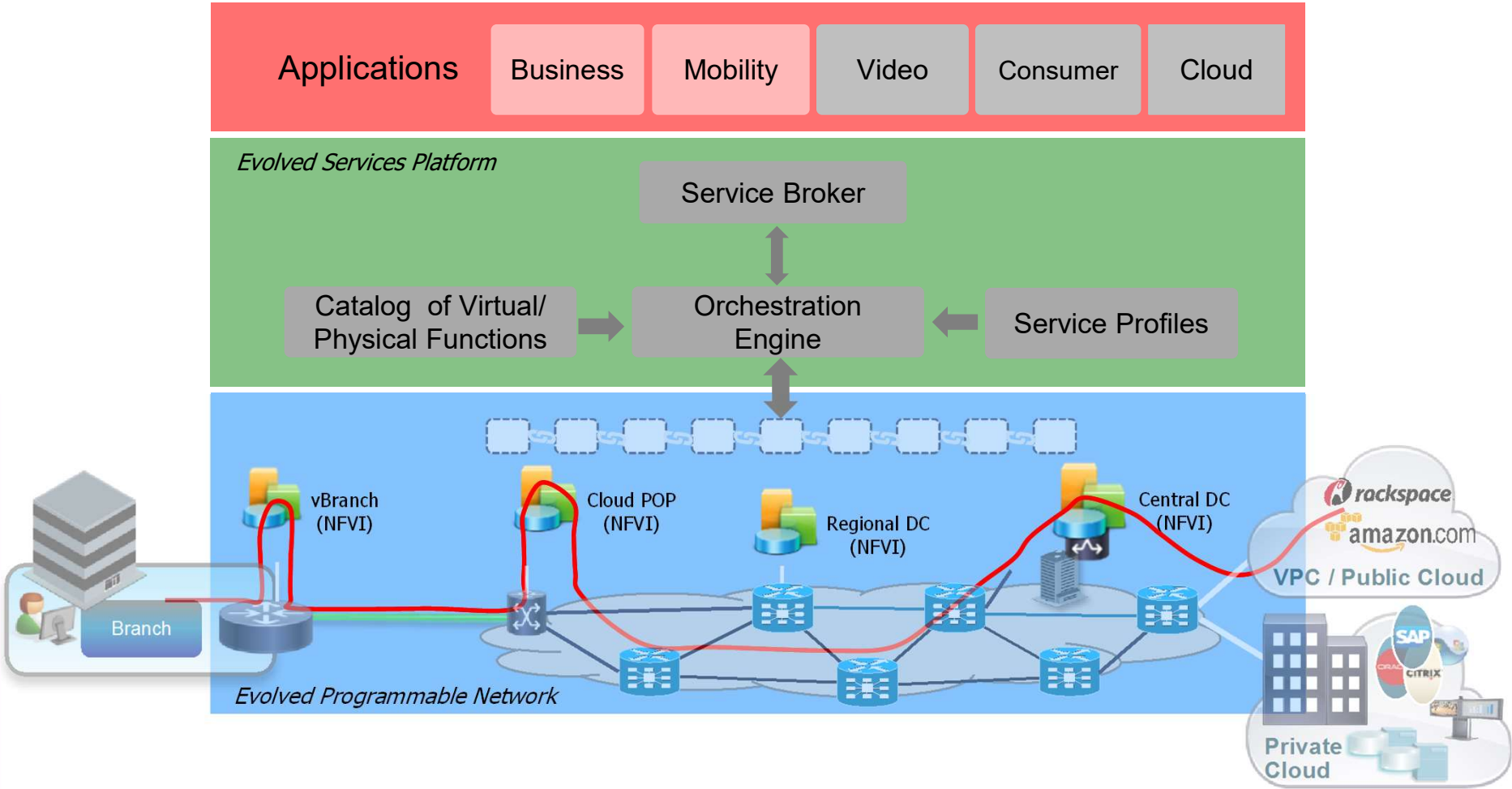
Cloud Data Center (CDC)

Challenges introduced by NFV (Network Function Virtualization)

- NFV implies a decoupling of the network functions from the supporting hardware
- Arbitrary distribution of service (network function) capabilities across the network
- NFV will allow a rapid and flexible deployment of services
 - Then rapid and flexible network connectivity is required
 - ... in an optimal way

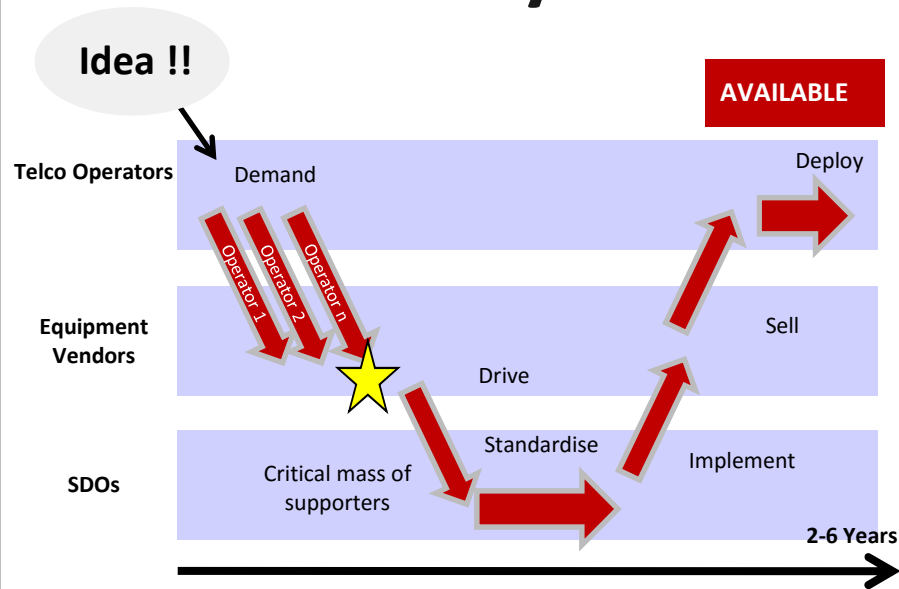


NFV Infrastructure



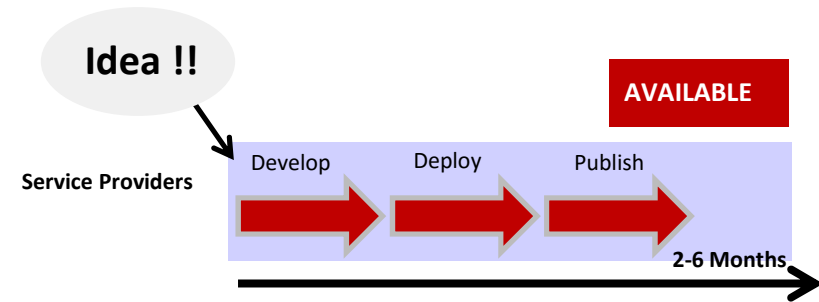
Telco Cycle vs OTT Service Provider Cycle

Telco Cycle



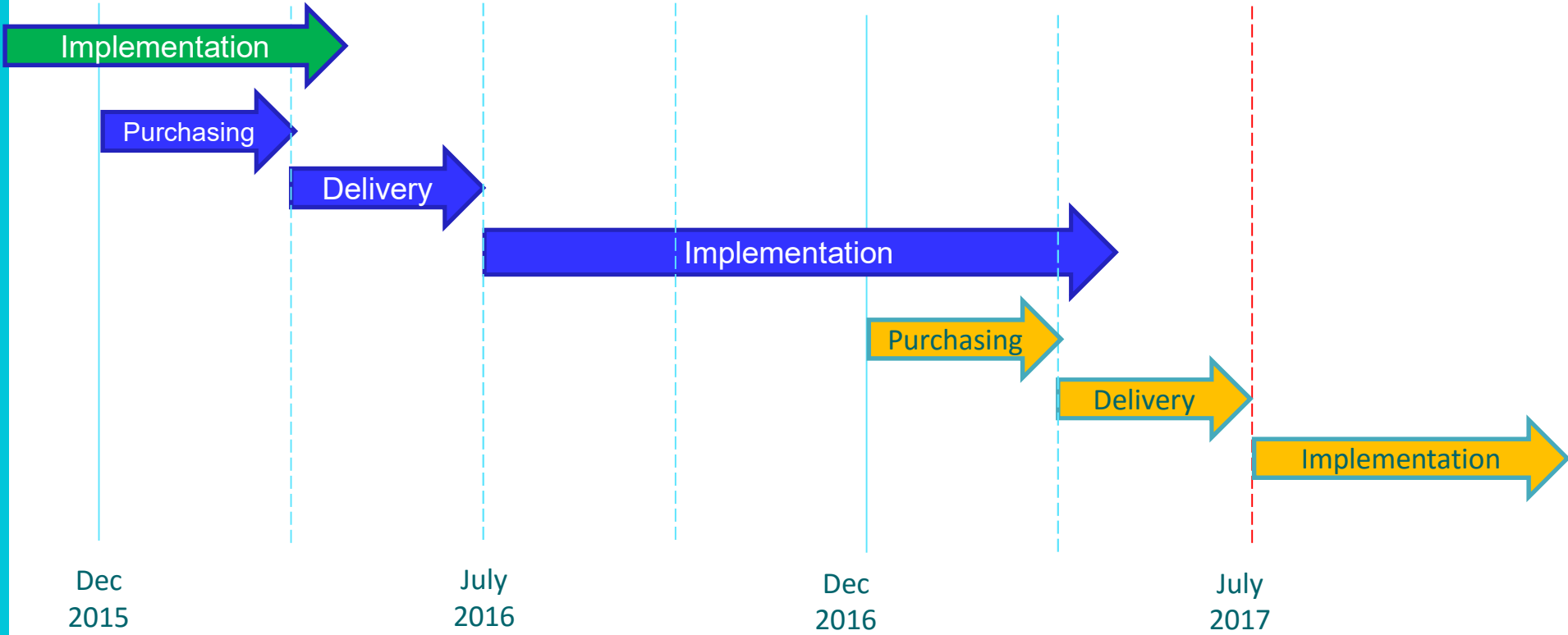
2-6 years

OTT Service Providers Cycle



2-6 months

Actual delivery cycle for one Telefonica's operation



Company name

The reality of an operator like Telefónica translates into ...

- Complex procedures for service delivery
- Difficulties on defining and standardizing services across the group
- High customization during service creation
- Slow adaptation of the network to changing demands
- Long time-to-market

Network Programmability is expected as the solution (or mitigation) for all of the above issues

SDN as a way towards network programmability

- Existing service innovation is tightly coupled to the product innovation cycles
 - High variety of vendors in operators like Telefónica, each of them presenting different operating systems, SDKs and APIs, in multiple node families and functionalities
 - Closed solutions per vendor, difficult to port
- Lack of automation in service delivery
 - Complex procedures for service scaling in and out

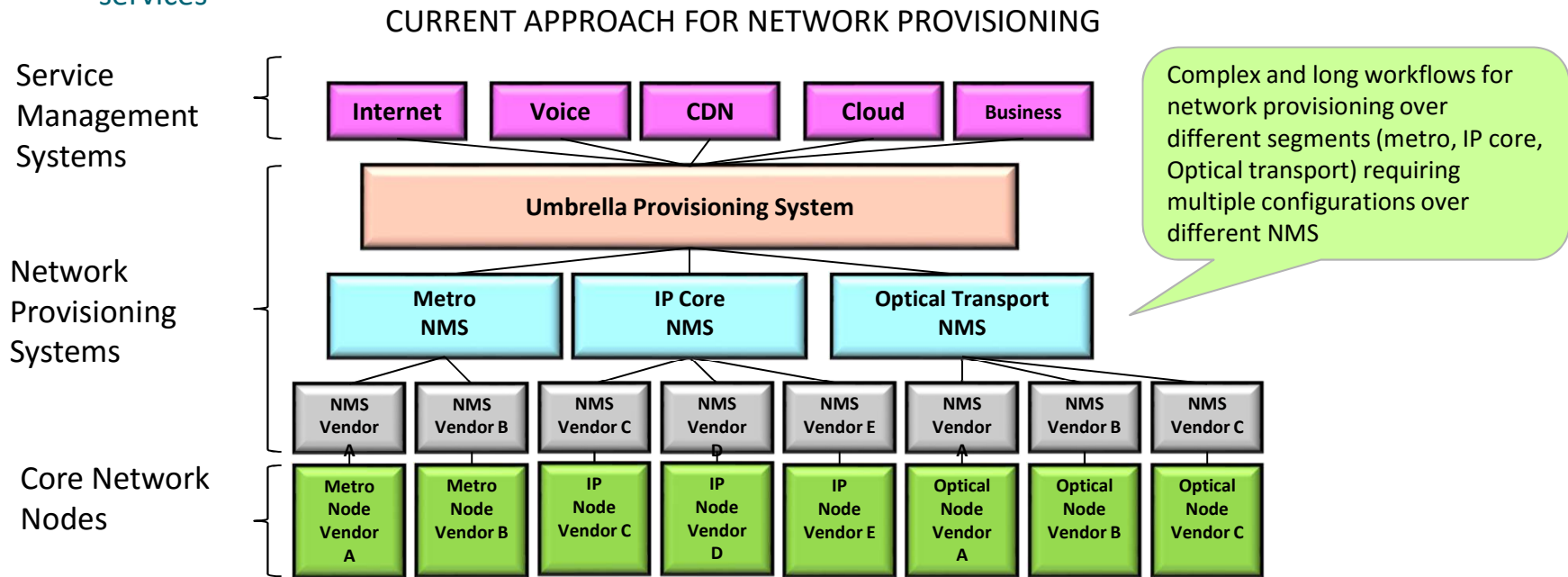
-
- Network programmability as the capability of **installing and removing network behavior**, in real time
 - This is **not just to populate rules** to simple switches or offering APIs
 - **End-to-end network abstraction is required** for true technology and vendor integration
 - Network **services to be realized by programming** instead of re-architecting the network
 - **Leveraging on** existing and deployed network capacities (**control plane functionalities**)
 - Managing the network in an **integrated/coordinated way, not as a collection of individual boxes/layers**
 - **Stress on service modeling and network modeling**, lately propagated through standard interfaces (Netconf, Yang, OpenFlow) cooperating with existing control plane capabilities (GMPLS, etc.)

02 

SDN in
Transport
Networks

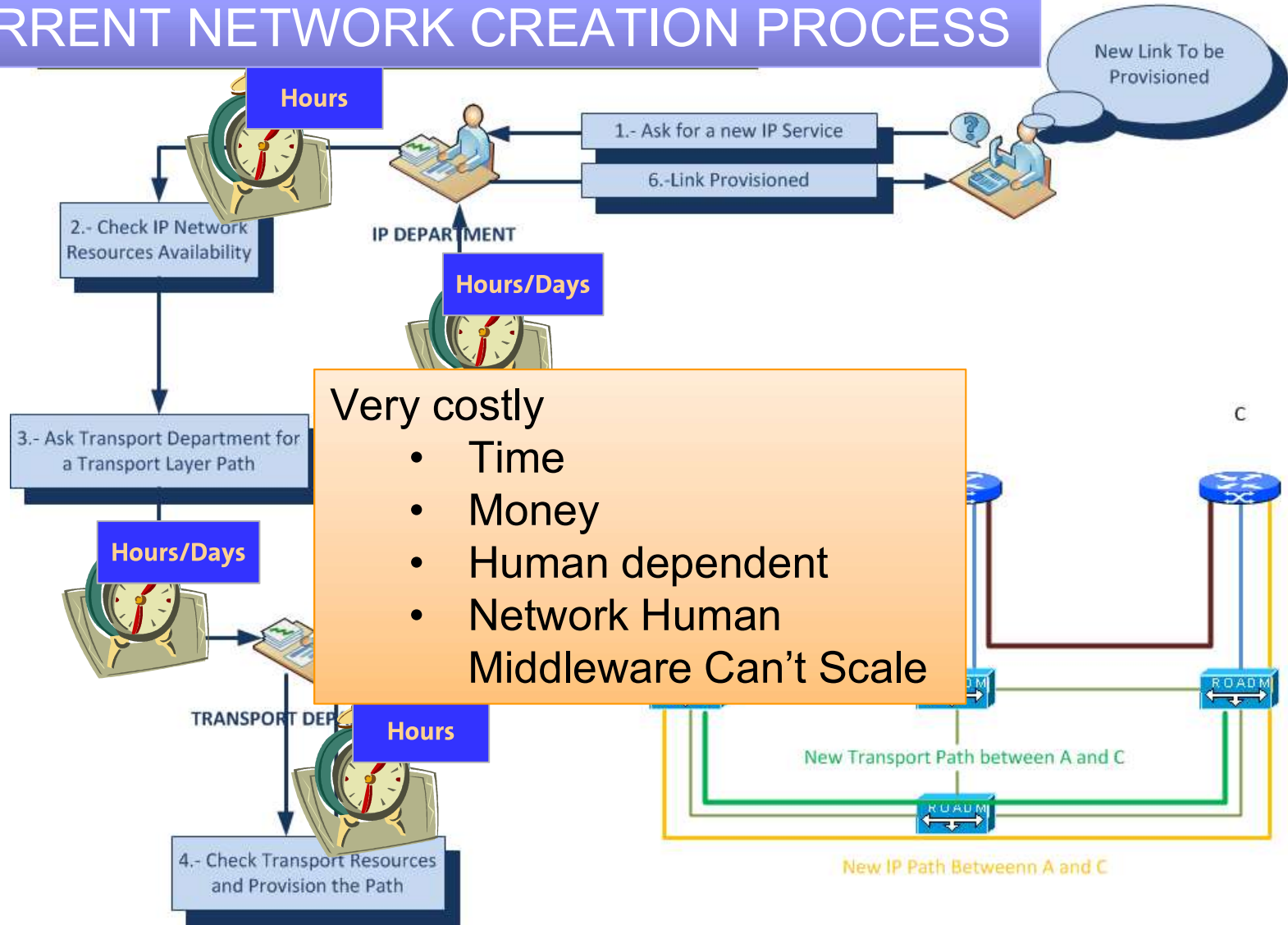
Traditional core network operation

- Core network operation is not adapted to flexible networking
 - Multiple manual configuration actions are needed in core network nodes
 - Hundreds of thousands of core nodes configurations per year in mid-size network operators (e.g ESP, BR)
 - Network solutions from different vendors typically use particularized Network Management System (NMS) implementations
 - More than 8 specific management implementations for service provisioning in multivendor core networks (e.g ESP)
- Very long service provisioning times
 - Up to two weeks for Internet service provisioning. More than 6 weeks for core routers connectivity services



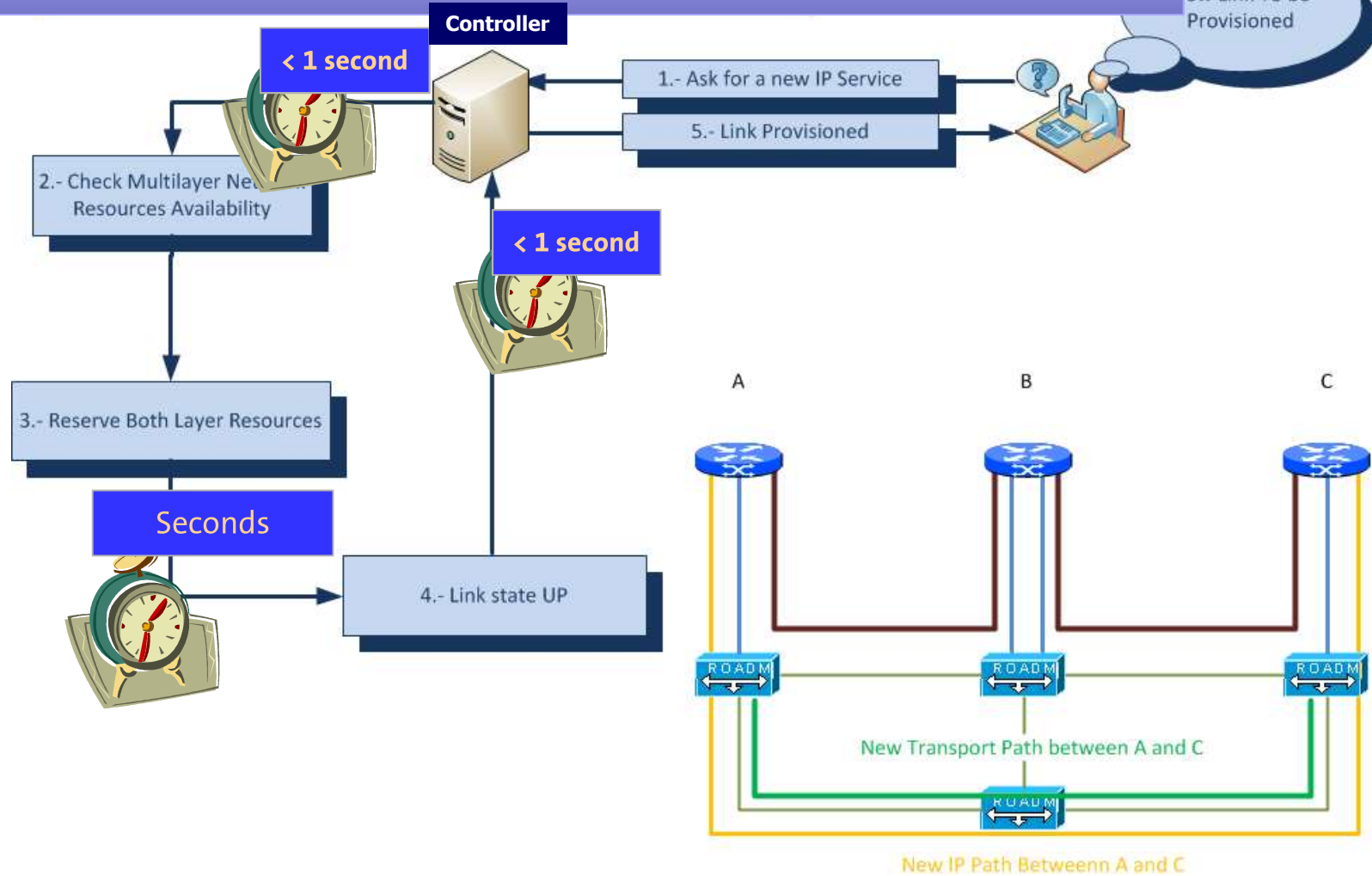
Automated Network Creation

CURRENT NETWORK CREATION PROCESS



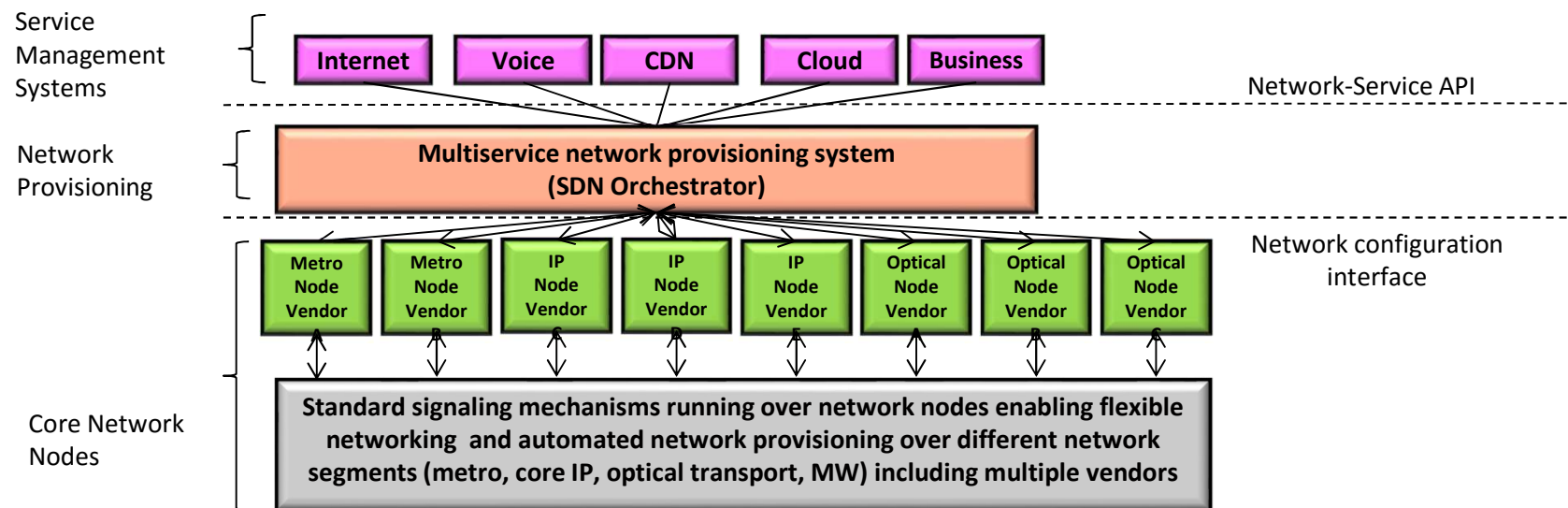
Automated Network Creation

AUTOMATED NETWORK CREATION PROCESS



Elastic core network operation

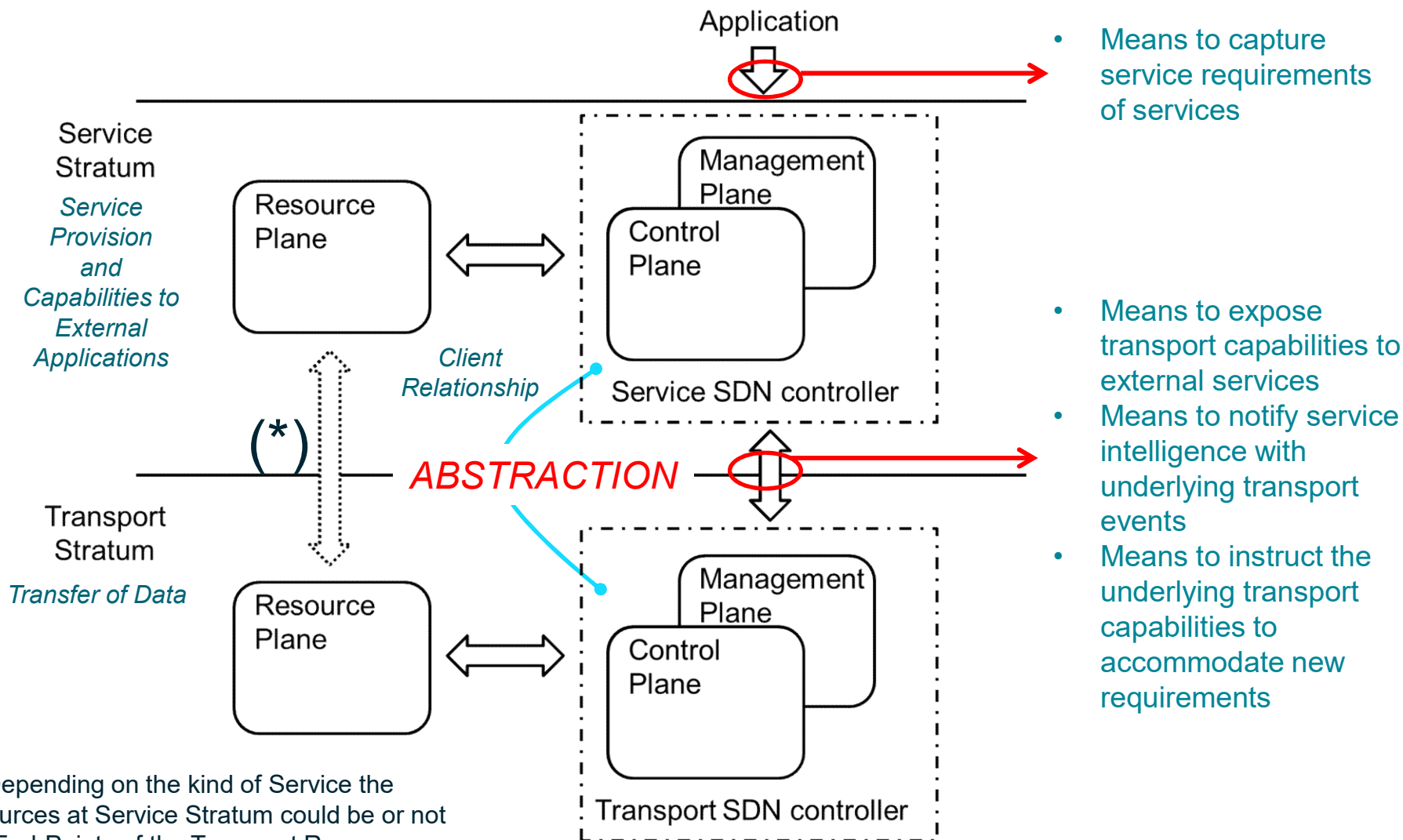
- Evolution towards an Elastic Core Network paves the way towards a unified network provisioning architecture
 - Multiservice provisioning
 - Automated multidomain/vendor/layer operation by signaling
- Key building block of such unified network provisioning architecture are
 - Network configuration interface: Multivendor edge nodes configuration (e.g OLT and BRAS, IP core routers, Optical equipment, etc) by standard interfaces (e.g Netconf)
 - IT and network SDN orchestration: Coordinated network and datacenter resources control according to service requirements (e.g orchestrated Virtual Machine transfer among DCs)
 - Network-Service API: Application level API hiding details of the network



A critical view on generic SDN Control architecture

- Existing proposals for SDN centralize control capabilities with very different objectives and purposes
- No separation between services and transport control
 - No clear responsibility for service provision and delivery
 - Complicated reutilization of components for delivering different services
 - Monolithic control architectures, driving to lock-in
 - Difficult interoperability, then difficult interchange of some modules by others
 - No clear business boundaries
 - Complex service/network diagnosis and troubleshooting

Cooperating layered architecture

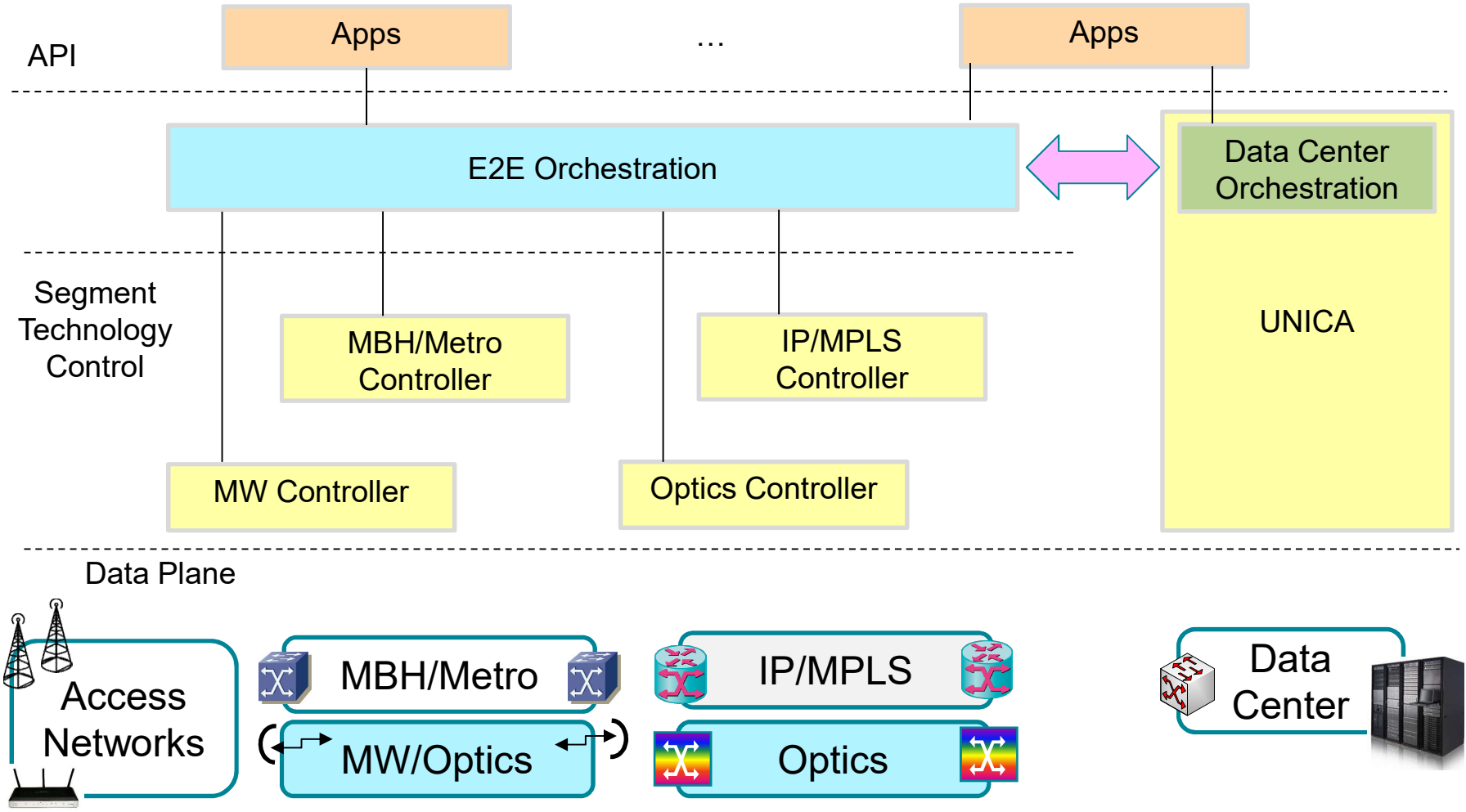


- Means to capture service requirements of services
- Means to expose transport capabilities to external services
- Means to notify service intelligence with underlying transport events
- Means to instruct the underlying transport capabilities to accommodate new requirements

(*) Depending on the kind of Service the resources at Service Stratum could be or not the End-Points of the Transport Resources

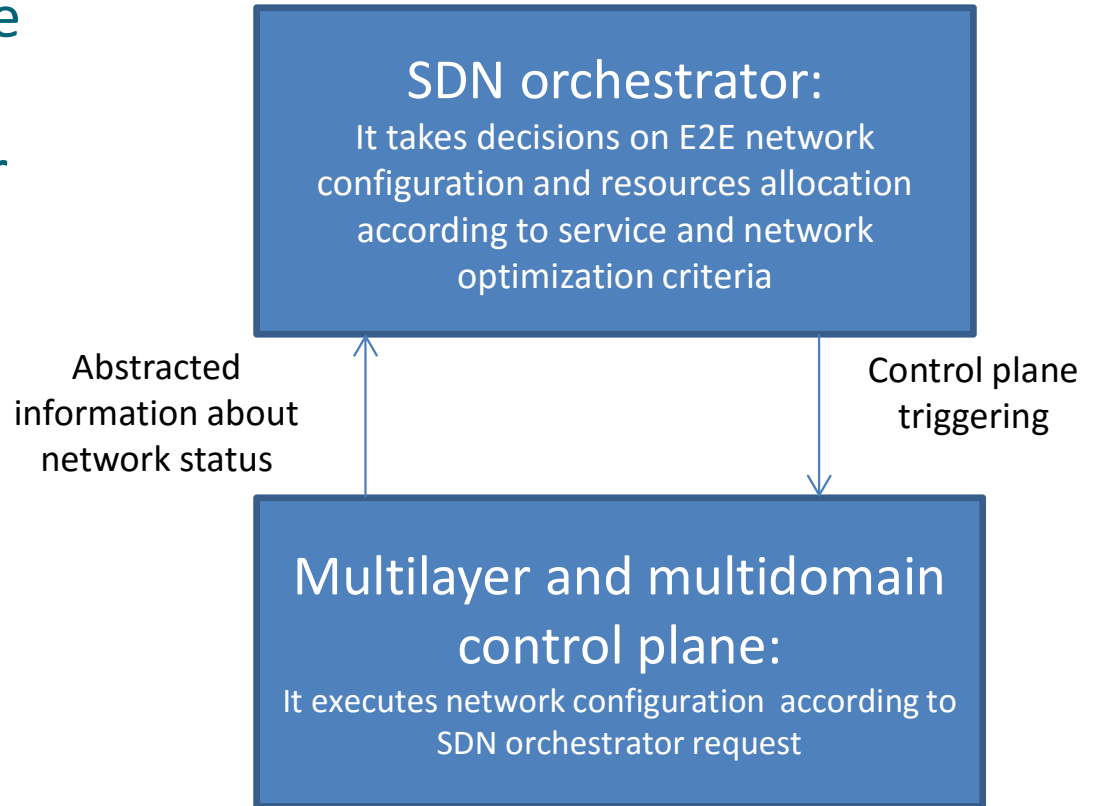
Source: L.M. Contreras, et al. "Cooperating Layered Architecture for SDN (CLAS)", draft-irtf-sdnrg-layered-sdn-00, Mar. 2016

E2E SDN Orchestration



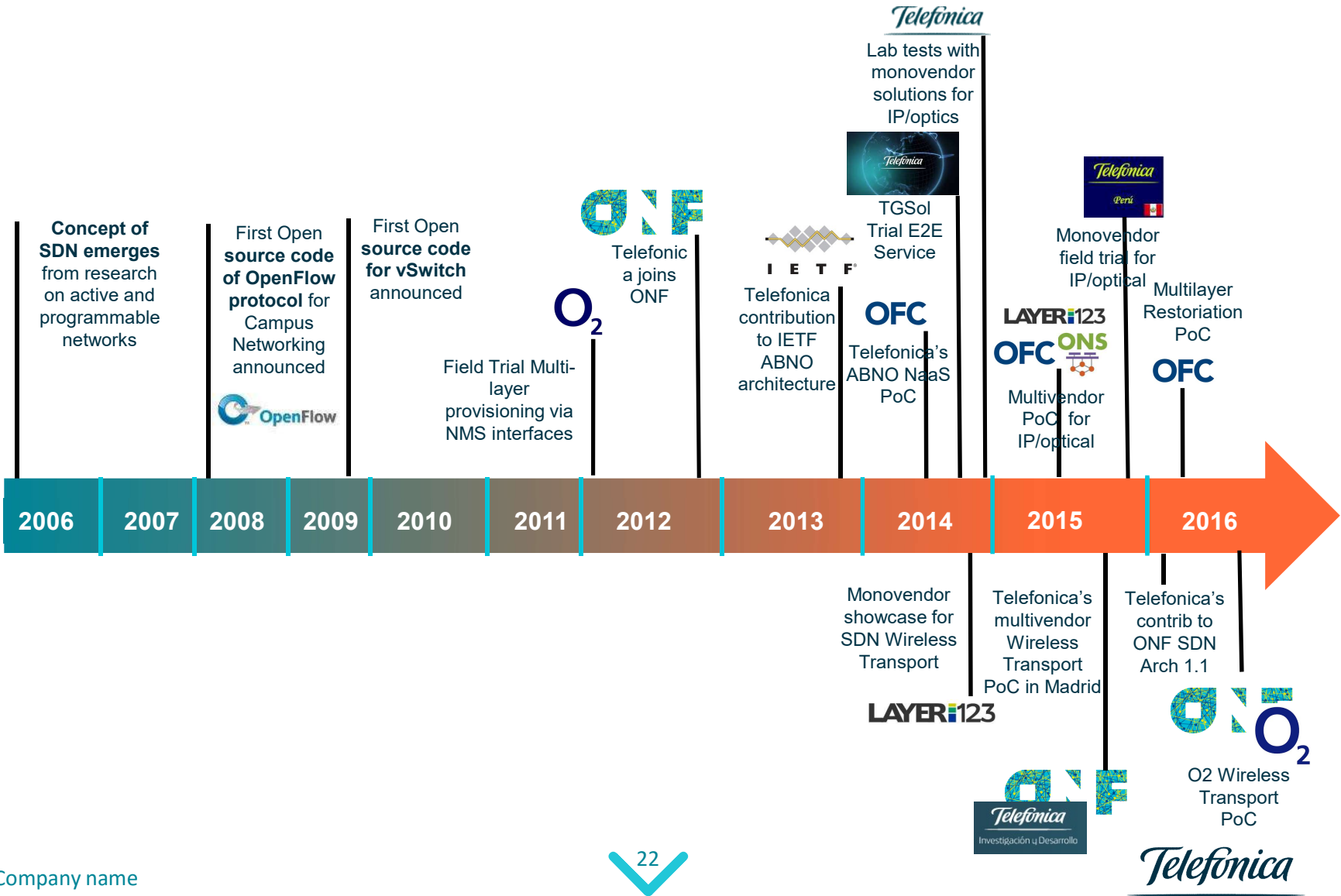
SDN orchestration approach

- Current SDN solutions are mainly focused on single domain and monovendor scenarios.
- SDN architectures for heterogeneous networks with different technologies (IP, MPLS, Ethernet, optical, MW...) and interfaces are still under definition.



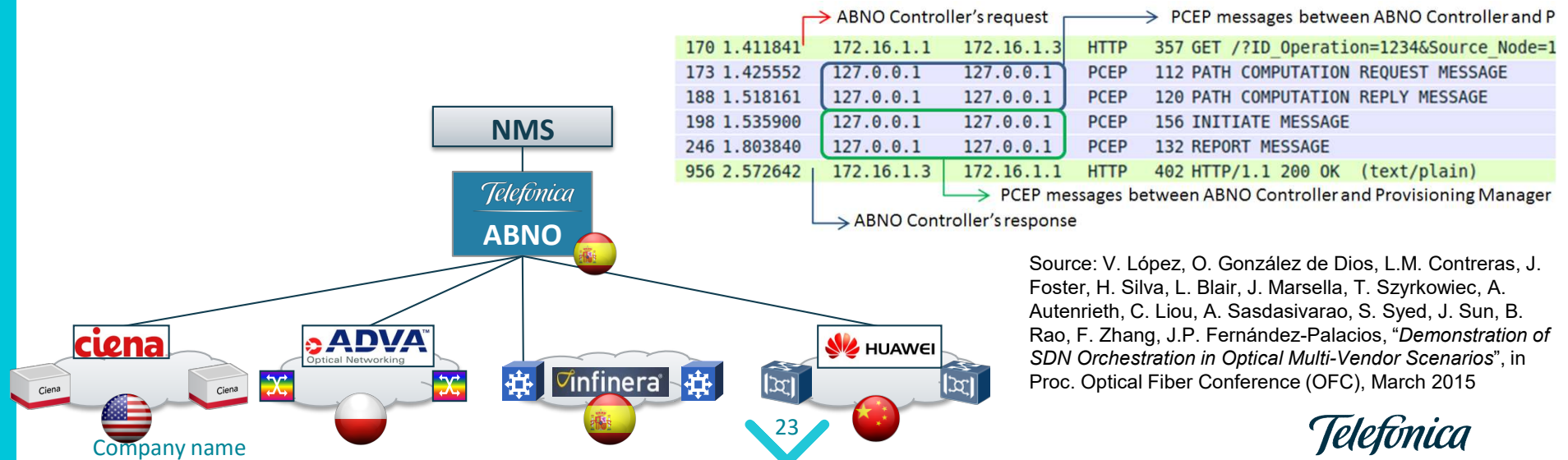
Common Information Models are key to achieve the proper level of abstraction among vendors, facilitating a common and unique control of the network elements

History Telefonica's activities for SDN applied to Transport Networks



Multi-vendor scenarios

		REST API 1	REST API 2	REST API 3	REST API 4
Provisioning	End Points	Supported	Supported	Supported	Supported
	Explicit Route	Roadmap	Roadmap	Supported	Supported
	Route Restrictions	Supported	Roadmap	Supported	Supported
	Service Protection	Supported	Roadmap	Roadmap	Supported
	Bandwidth	Supported	Roadmap	Supported	Supported
	Disjoint paths	Supported	Roadmap	Supported	Supported
Topology	Network Identifiers	Supported	Supported	Supported	Supported
	Physical Links	Supported	Roadmap	Supported	Supported
	Virtual Links	Supported	Supported	Roadmap	Roadmap
	Resource occupation	Supported	Roadmap	Supported	Supported
	Physical impairments	No use cases	Not supported	No use cases	Supported
Monitoring	Network status	Supported	Not supported	Supported	Supported
	Alarms, events	Roadmap	Not supported	Supported	Roadmap
	Path Computation	Supported	Roadmap	Supported	Supported



Source: V. López, O. González de Dios, L.M. Contreras, J. Foster, H. Silva, L. Blair, J. Marsella, T. Szyrkowiec, A. Autenrieth, C. Liou, A. Sasdasivarao, S. Syed, J. Sun, B. Rao, F. Zhang, J.P. Fernández-Palacios, "Demonstration of SDN Orchestration in Optical Multi-Vendor Scenarios", in Proc. Optical Fiber Conference (OFC), March 2015

Do we need transport SDN?

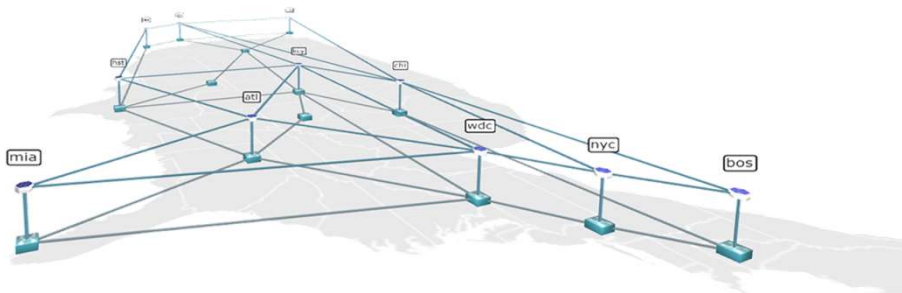
Where and when do we need to deploy a transport SDN solution

- Scenarios
 - L0/L1 service provisioning.
 - There no need to deploy SDN to have this scenario, NMS from vendors allow us to carry out such operation.
 - Configure L0/L1 parameters like protection, explicit route, etc.
 - Proprietary interface limits vendors competition.
 - Multi-vendor L0/L1 provisioning
 - Current solutions does not allow to setup connections in multi-vendor scenarios.
 - Restoration/protection should be maintain in this multi-vendor scenario.
 - Standard interfaces required for enabling this.
 - Service provisioning to third parties
 - Multi-layer scenarios, data center interconnections are limited due to the fact that the provisioning process is not automated.
 - Centralized inventory and topological information can lead us to savings.

Use Cases that can be enabled

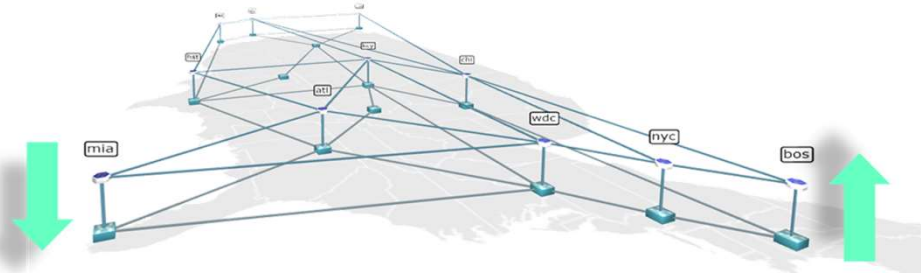
Multi-layer discovery and visibility

- Learn topology and traffic in each layer
- Automatically learn cross layer mapping
- Always-accurate network view



Cross-layer awareness

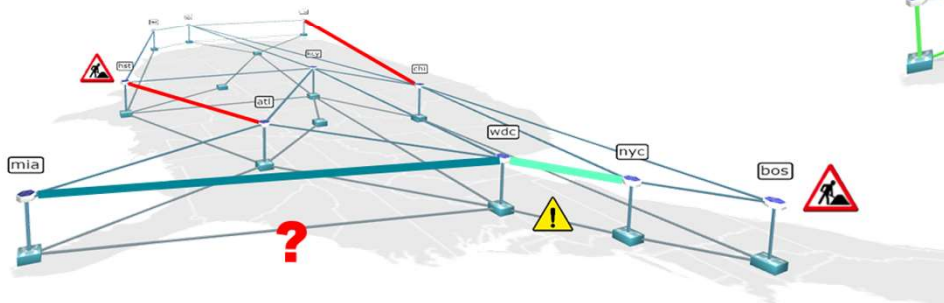
- Basic: provision L3 links with optical SRLGs
- Advanced: reroute optical connections to provide more diversity
- Reduced service downtime



Use Cases that can be enabled

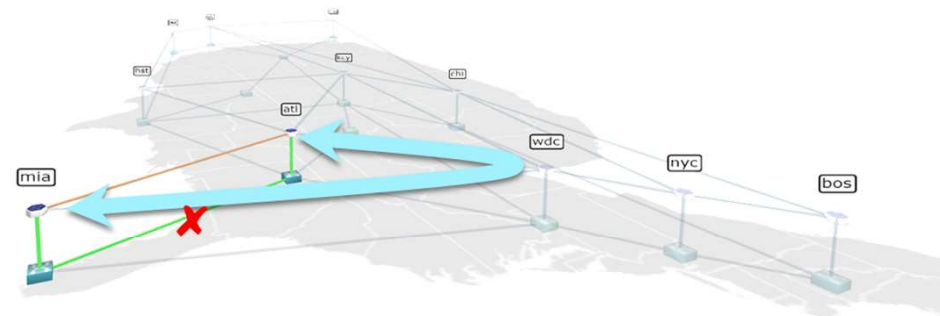
Coordinated maintenance

- Basic: accurately predict the impact of a maintenance activity
- Advanced: minimize impact of maintenance activity in a proactive manner
- Safe Operation



Restoration

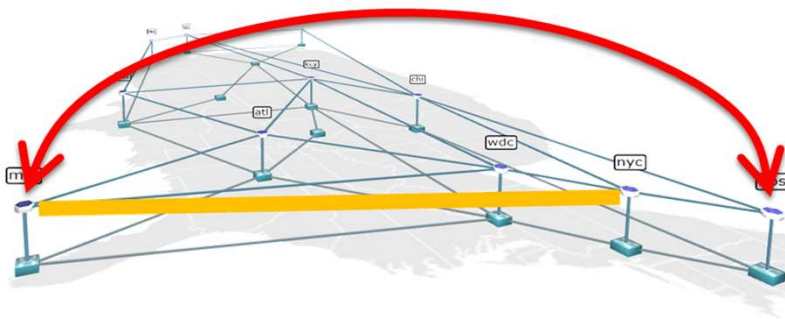
- Basic: Control IP links to be restored and their order
- Advanced: Control failures between domains
- CAPEX savings



Use Cases that can be enabled

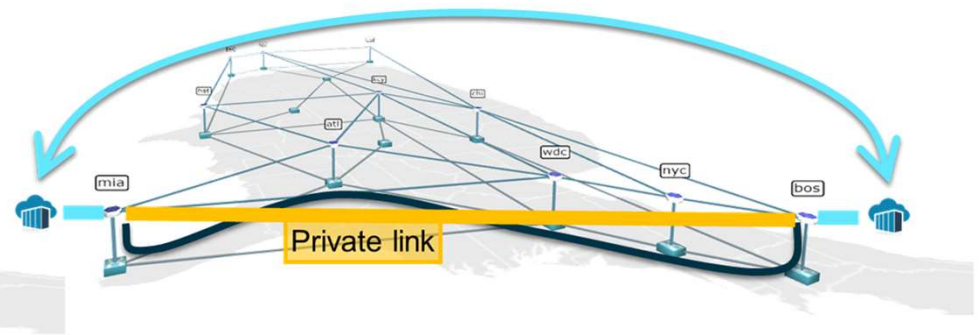
Optimization

- Basic: Add IP links and their optical path based on traffic needs
- Advanced: Rearrange network to optimize use of IP and optical resources
- Adaptive network



Enterprise Services

- Basic: manually add IP link and its optical path based on user input
- Advanced: automatically add IP link based on API from external cloud app
- Economical 10/100G BoD



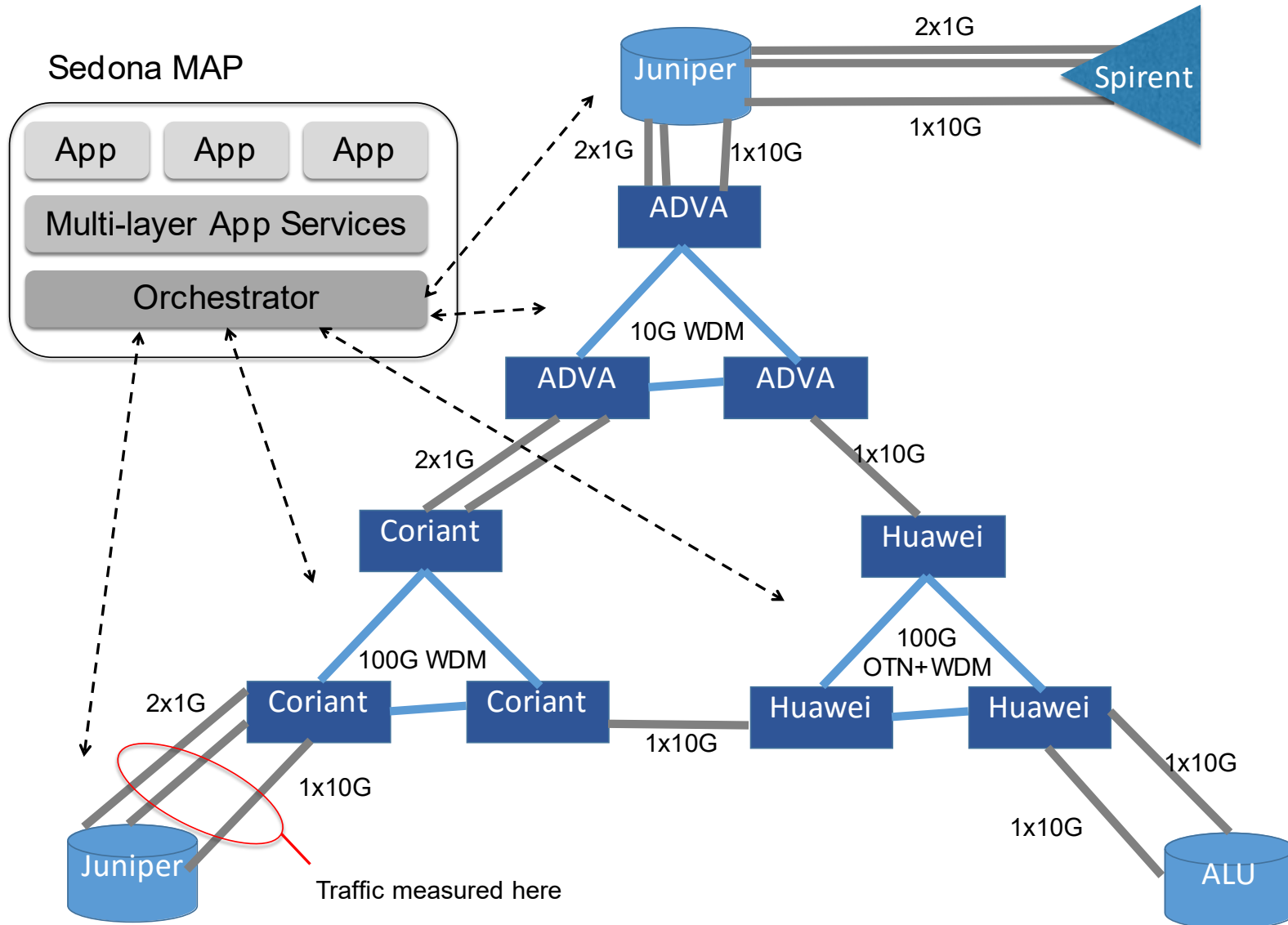
OFC 2016 Demo

- Live demo at the Sedona booth at OFC
- Running on commercial gear in Telefonica's GCTO lab
- Multiple IP layer vendors: Nokia, Huawei & Juniper
- Multiple optical layer vendors: Coriant, Adva & Huawei
- Most equipment controlled through the vendor's SDN controller
- Multi-layer and multi-vendor behavior orchestrated via the Sedona multi-application platform (MAP)

What was demonstrated?

- Automatic L0-L3 network discovery and mapping:
 - Showing both IP and optical layers, and their cross links, on a single live map
- Review & simulation of the restoration plan:
 - Understand the pre-defined restoration plan in the network step by step
- Integrated multi-layer restoration:
 - Automated manipulation of IP and optical layer resources to restore from a failure in a cost-effective manner, exploiting the optical layer to restore capacity around a failure, in a way that best meets the needs of the IP layer
- Hitless revert after the failure has been fixed:
 - A unique ability to return the network to its original state after the failure has been fixed, in a way that does not affect IP services, allowing for the automation of the process

Demo OFC 2016



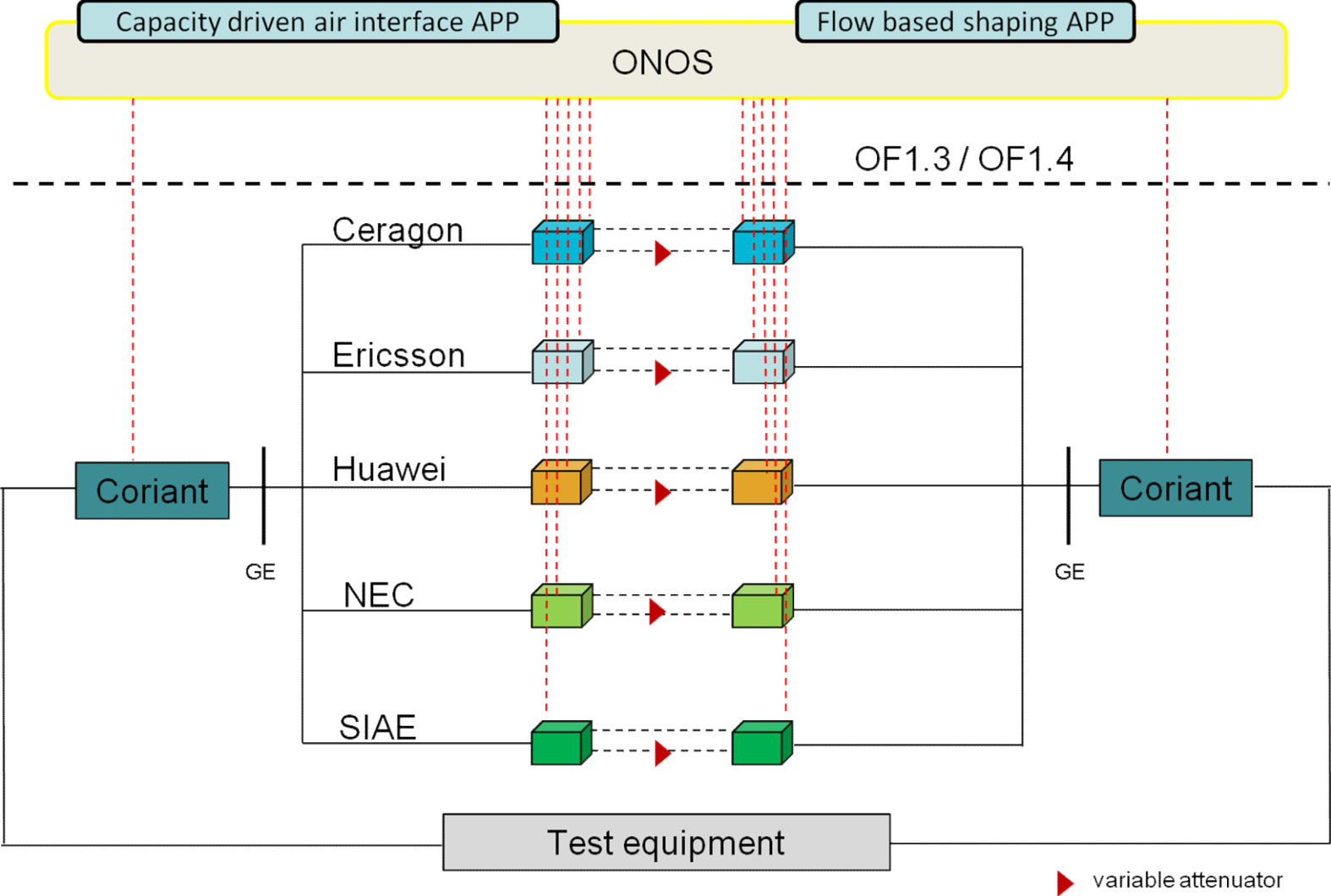
Motivation, Framework and Opportunities for applying SDN for MW

- Motivation
 - ✓ Road to simplification: No common way of controlling and managing Wireless Transport Networks (e.g. Microwaves)
 - ✓ Road to automation: No advanced control plane features for rich functionalities nor multilayer coordination (SDN as an enabler)
- Framework
 - ✓ Work to define a (unified and standard) control plane for Microwave systems
 - ✓ Multi-vendor interworking, multi-layer control, network-wide coordination
- Foreseen Opportunities
 - ✓ Common operation of multi-vendor environments
 - ✓ Innovative Ecosystem for deployment of advanced applications
 - ✓ Multi-technology / Multi-layer coordination
 - ✓ Adaptation of the MW resources to the real traffic demand

First PoC Use Cases for application of SDN to Wireless Transport Networks

- Capacity driven air interface
 - ✓ It shows how the SDN controller optimizes the total power consumption in a wireless transport network
 - ✓ The controller disables underlying physical ports of wireless L1 LAG links when the utilization is below certain thresholds
 - The controller MUTE or UNMUTE physical ports (OFPWTIPPT_TX_MUTE)
- Flow basing shaping
 - ✓ Control of both wireless transport and switching equipment from the same SDN controller
 - ✓ The controller enables/disables policer on the router according to the observed wireless link capacity and some defined thresholds (OFPWTIPPT_TX_CURRENT_CAPACITY)

First PoC High Level Setup



First PoC team

Vendors



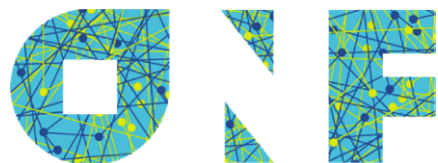
siae microelettronica

Controller



Organization and support

Standardization



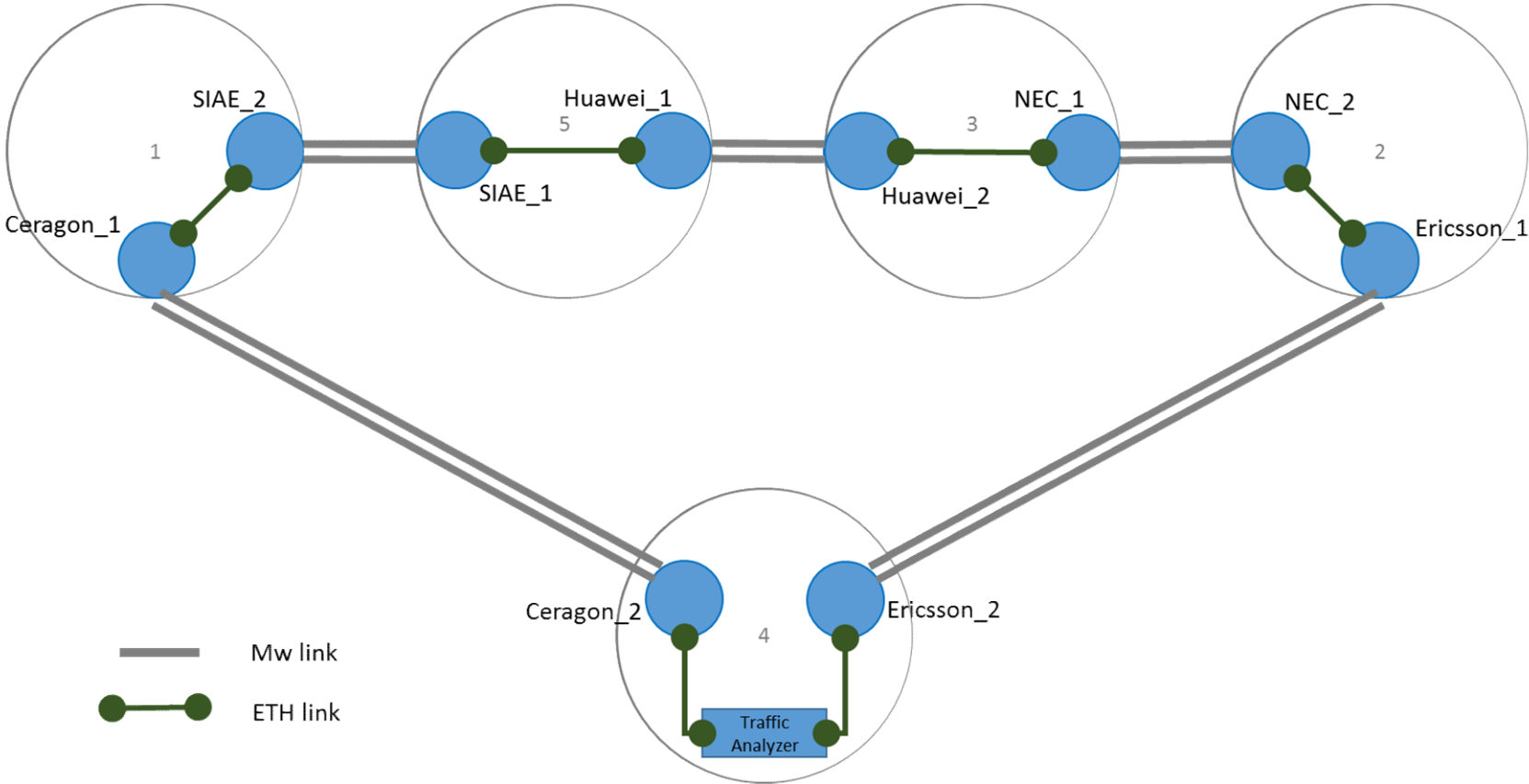
Universidad
Carlos III de Madrid

Company name

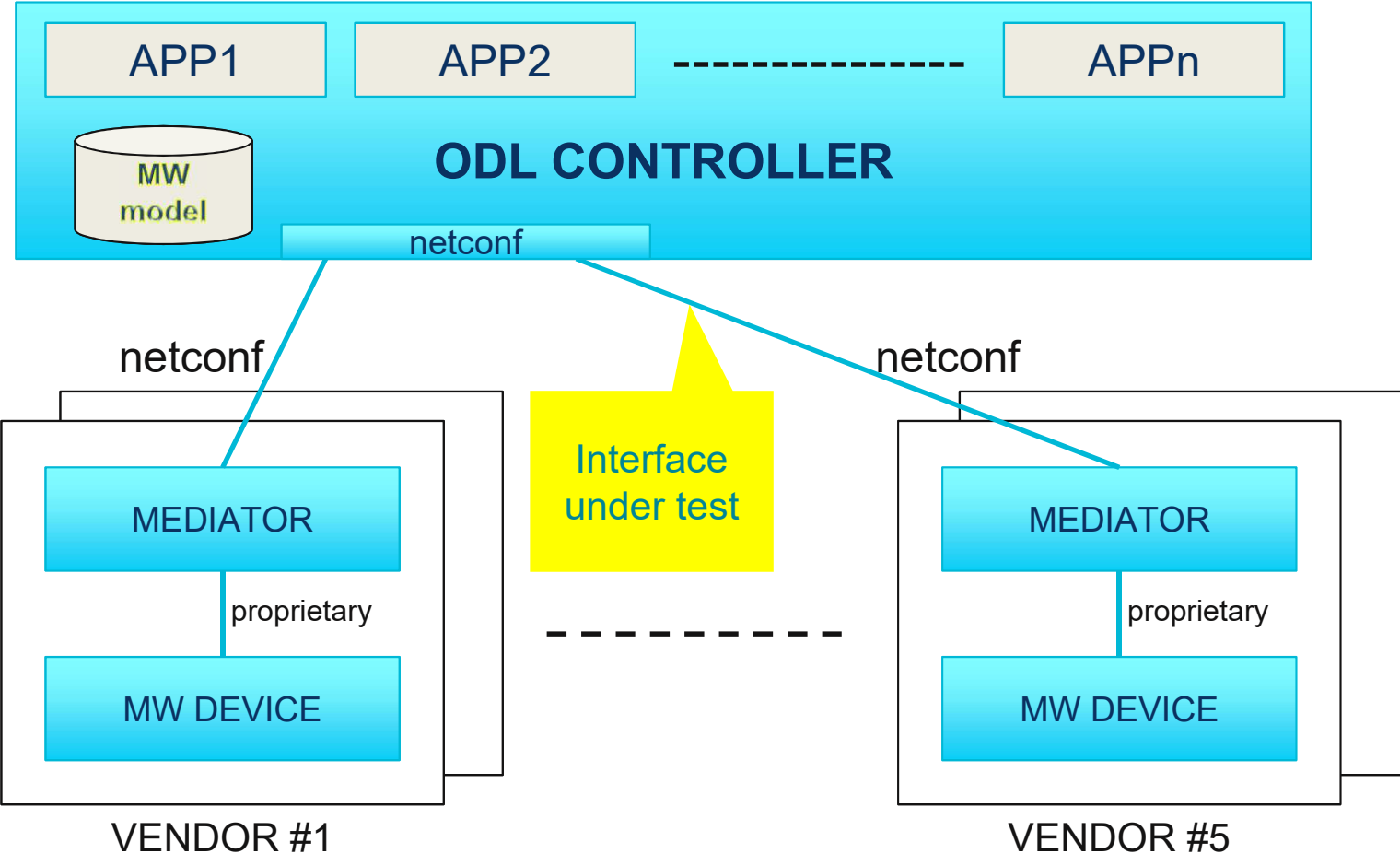
Second PoC Use Cases for application of SDN to Wireless Transport Networks

- Detection and configuration of new microwave devices
 - Automated detection of NEs and making them available for configuring
- Detection of aberrances
 - Comparing the actual network configuration with external reference data, informing about aberrances and offer correction
- Detection and Visualization of the configured microwave network
 - Graphical overview about the momentarily configured network (= time variant in SDN managed network)
- Detection and Visualization of the currently effective network
 - Graphical overview about the momentarily actually effective network, highlighting deviations from the configured network
- Receiving and displaying of alarm information
 - Listing of events

Network Topology for the Second PoC



Network Architecture for the Second PoC



Second PoC Participants

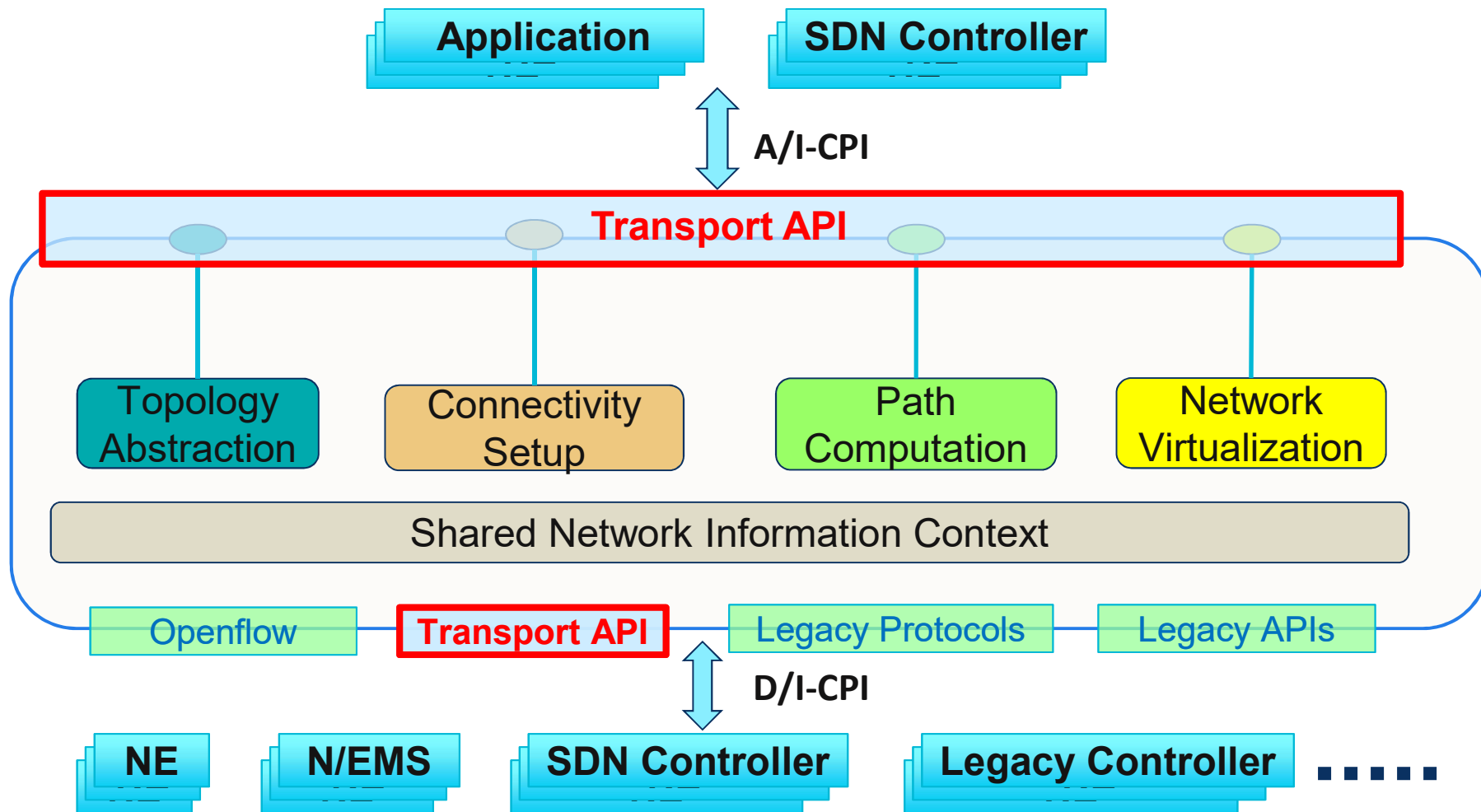
- Operators, who provided content and organizational support:
 - Telefónica,
 - AT&T
- Microwave vendors:
 - Ceragon
 - Ericsson
 - Huawei
 - NEC
 - SIAE
- Integrators and Application Providers:
 - Highstreet Technologies,
 - Wipro,
 - Tech Mahindra
 - HCL
- Other Participants:
 - Viavi, ZTE, Deutsche Telekom



Transport API

- Project chartered under ONF Open Transport WG (Specifications Area)
- Objective – realize the software-centric approach to standardization
 - Purpose-specific APIs to facilitate **SDN control of Transport networks**
 - Focus is on **functional aspects** of transport network control/mgmt
 - Target is **YANG & JSON** API libraries
- Scope – based on purpose-specific use case discussions
 - **Topology Service**
 - Retrieve Topology, Node, Link & Edge-Point details
 - **Connectivity Service**
 - Retrieve & Request P2P, P2MP, MP2MP connectivity for (L0/L1/L2) layers
 - **Path Computation Service**
 - Request for Computation & Optimization of paths
 - **Virtual network Service**
 - Create, Update, Delete Virtual Network topologies
 - **Notification Framework**
- Only technology/layer-independent common characteristics for initial release

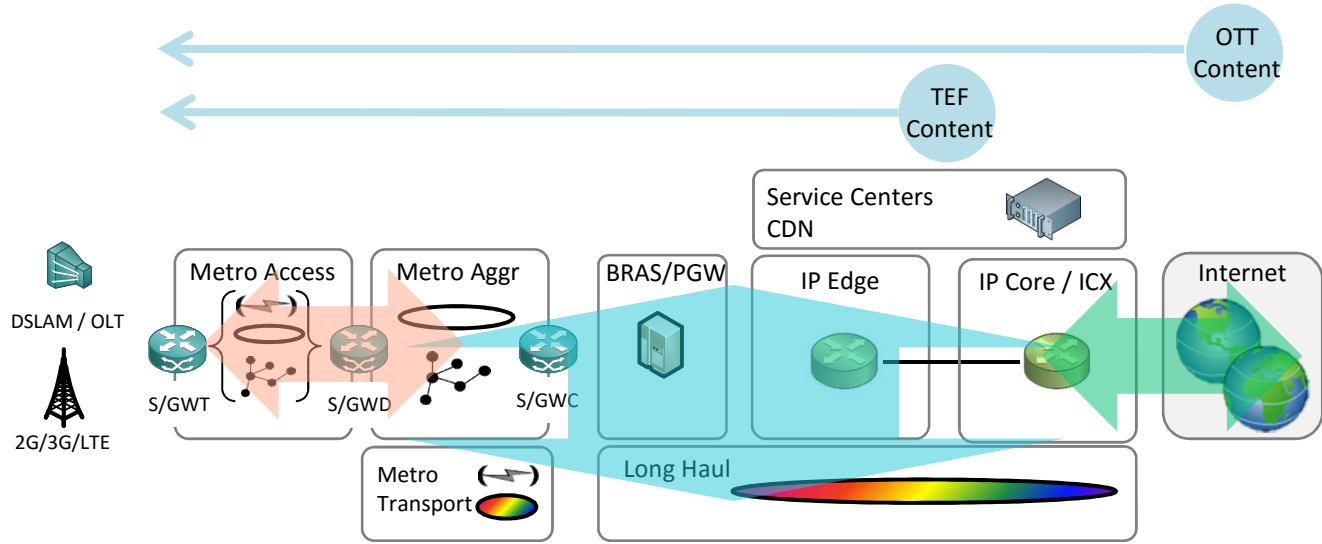
Transport API – Functional Architecture



03 

On-going
Innovation
Actions

Ongoing Innovation Actions

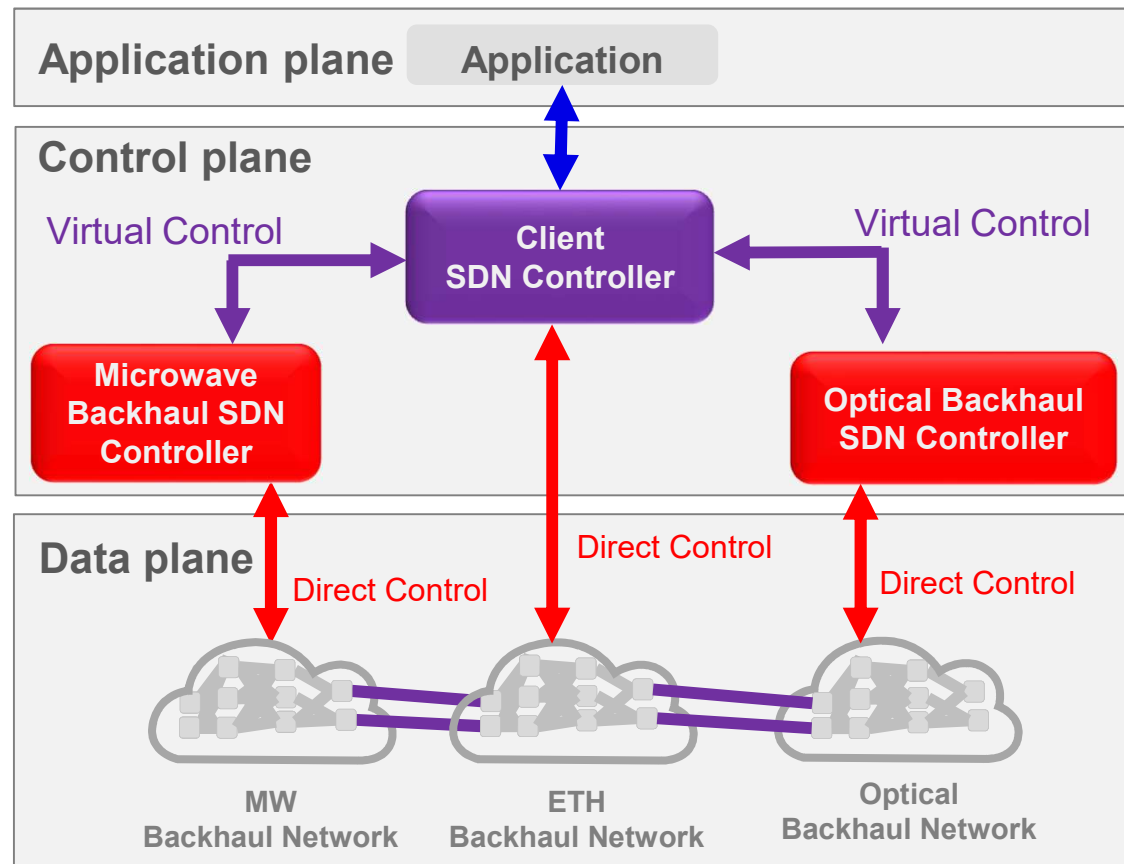


- 5G-Crosshaul
- ACINO
- 5GEx

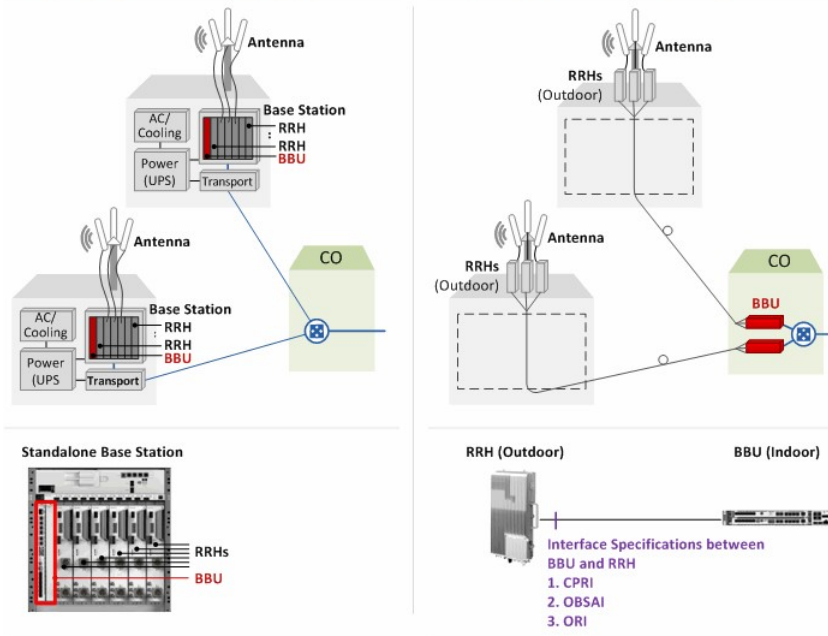
Mobile Backhaul

- Separate, independent layers do not allow overall optimization
 - Multilayer approach for performing combined optimization
- Separated domains complicate the service provisioning and network adaptation
 - Interconnection of controllers for e2e optimization
- Separated control and management mechanisms require multiple interventions
 - Standard interfaces simplify heterogeneous device management

SDN control will allow the orchestration of the network resources



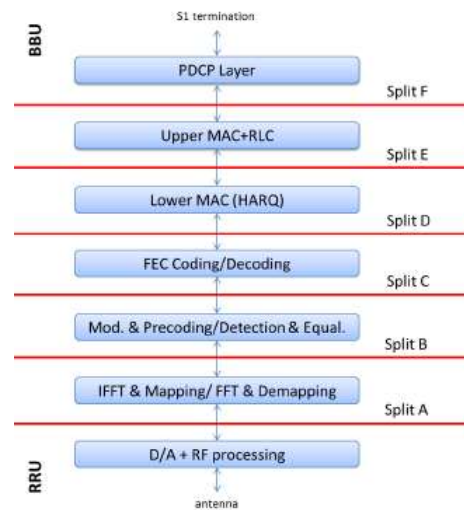
Before (D-RAN) (Standalone Base Station, Distributed RAN) → After (C-RAN) (Separated Base Station, Centralized RAN)



C-RAN

BBU units centralization for taking advantage of long distance CPRI interfaces in order to reduce cell site costs

Different functional splits have different implications

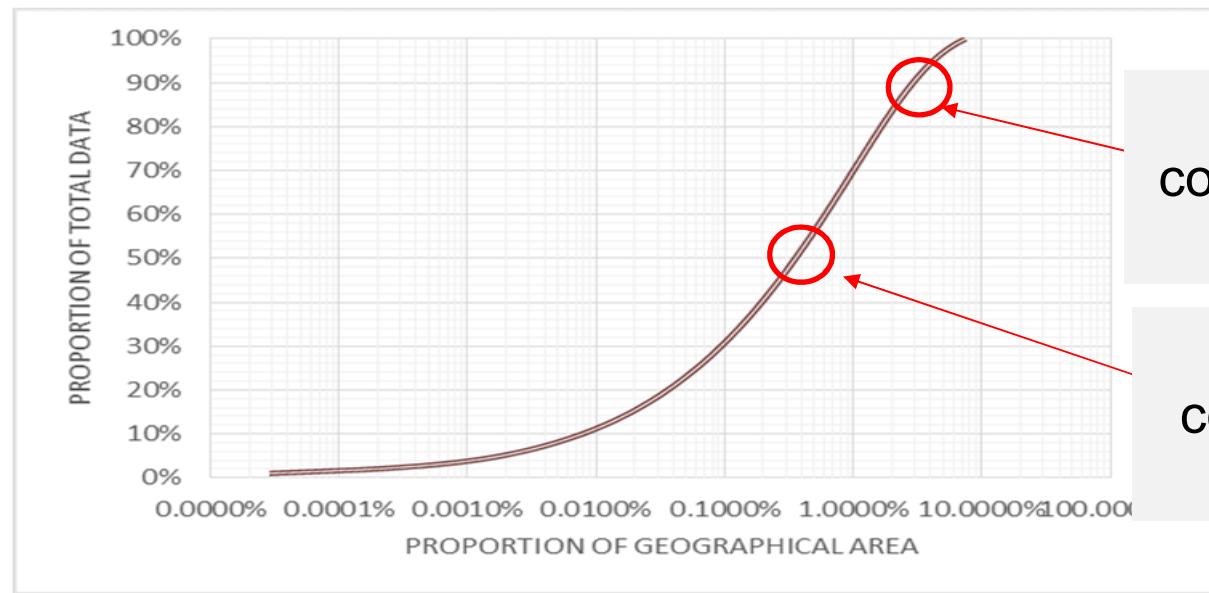


No.	Advantages/Disadvantages
F	<ul style="list-style-type: none"> Clean cut No centralized scheduling
E	<ul style="list-style-type: none"> No HARQ delay requirement for FH
D	<ul style="list-style-type: none"> Data rate depends on code rate per user Clean cut Potentially no hardware acc. at BBU No centralized joint decoding
C	<ul style="list-style-type: none"> Data rate depends on modulation scheme, layers per user No centralized CoMP, MU-MIMO
B	<ul style="list-style-type: none"> Only utilized RB (enables stat. mux.) No CP, GC on FH Potentially no RS, SS on FH Frequency domain (lower A/D res.) Additional hardware at RRU required (FFT)
A	<ul style="list-style-type: none"> CPRI No limitation in centralized processing Very little digital hardware at RRU Very high, static data rate Low latency required

Geographical non-uniformity of usage of the radio access

Data Consumption by proportion of area

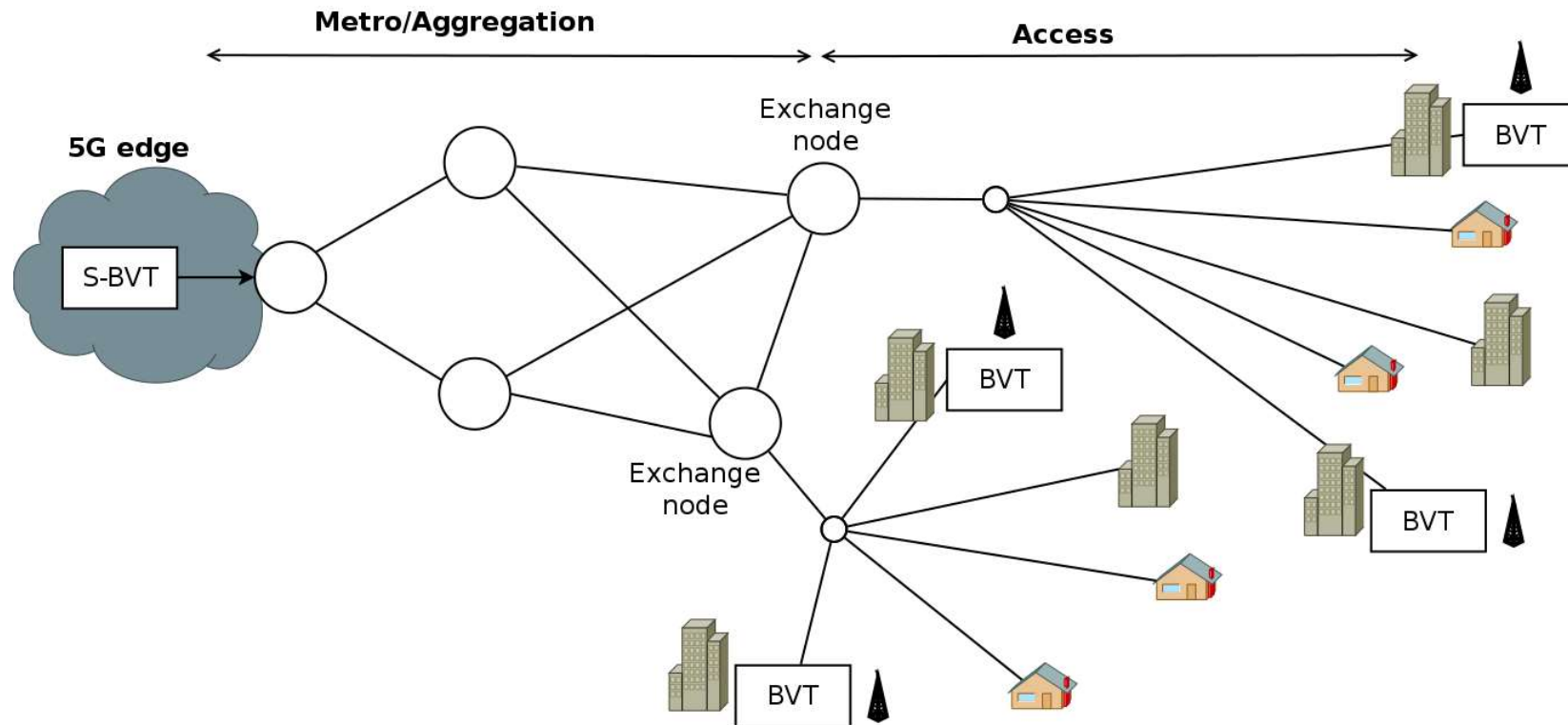
(Data from Viavi 2015 Study)



90% of the data is consumed in less than 5% of the area

50% of the data is consumed in less than **0.35%** of the area!

EON in the fronthaul



Main idea: Transparently and dynamically deliver mobile front-/back-haul in a converged metro/access environment, following the elastic networking paradigm while taking advantage of the already deployed fiber infrastructure

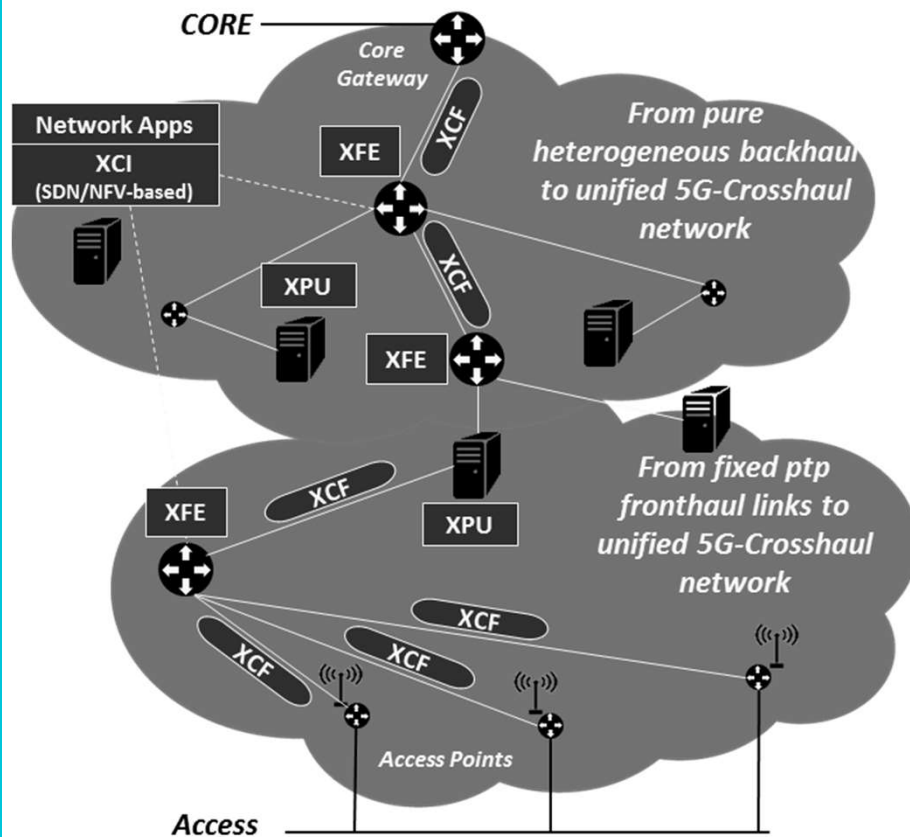
Taking action

5G-Crosshaul project⁽¹⁾

5G X Crosshaul
the integrated fronthaul/backhaul

(1) <http://www.5g-crosshaul.eu/>

A high capacity low latency transport solution that lowers costs and guarantees flexibility and scalability



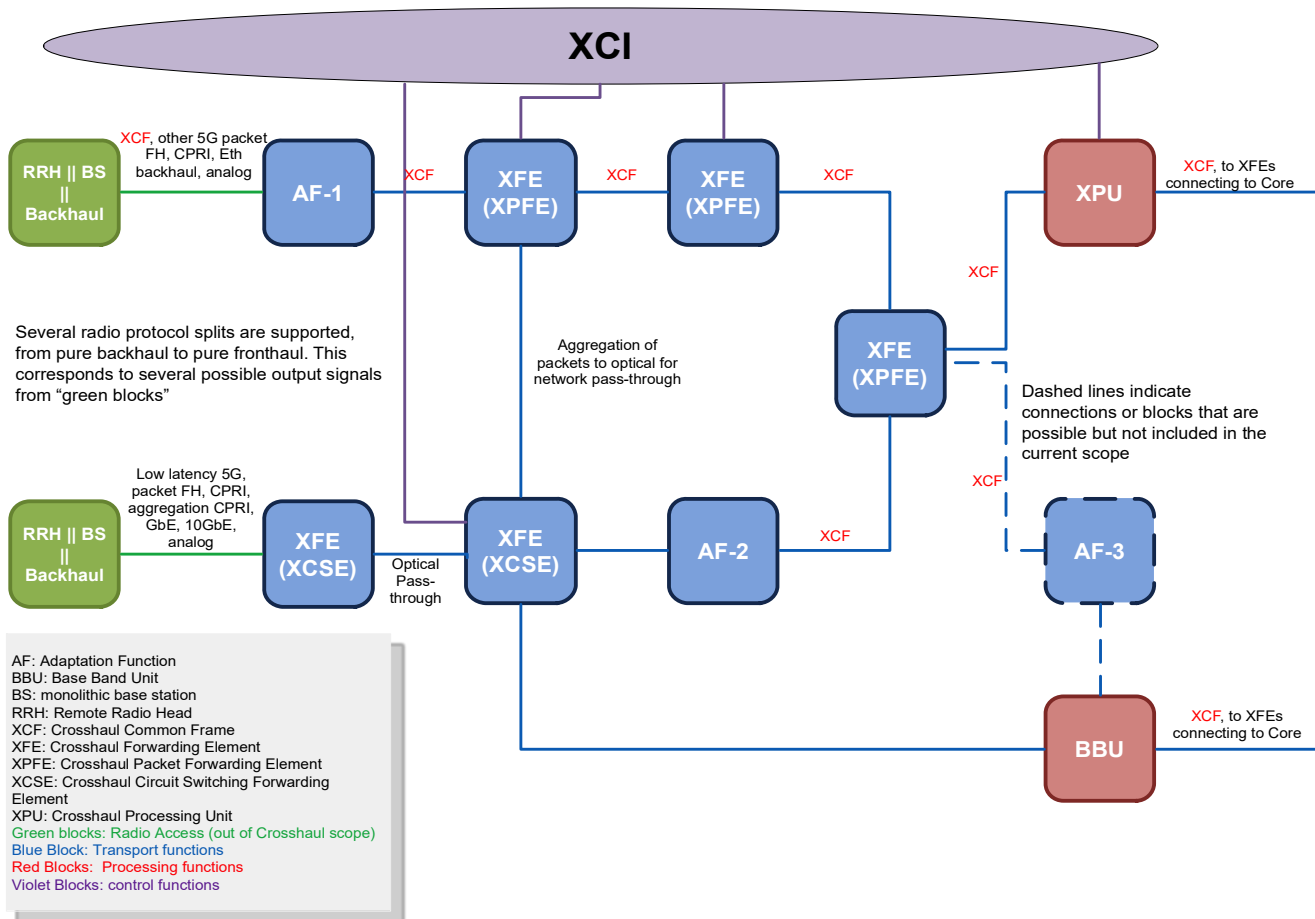
A holistic approach for converged Fronthaul and Backhaul under common SDN/NFV-based control, capable of supporting new 5G RAN architectures (V-RAN) and performance requirements

Main building blocks

- XCF – Common Frame capable of transporting the mixture of various Fronthaul and backhaul traffic
- XFE – Forwarding Element for forwarding the Crosshaul traffic in the XCF format under the XCI control
- XPU – Processing Unit for executing virtualized network functions and/or centralized access protocol functions (V-RAN)
- XCI – Control Infrastructure that is SDN-based and NFV-enabled for executing the orchestrator’s resource allocation decisions
- Novel network apps on top to achieve certain KPIs or services

Company name

The 5G-Crosshaul hybrid data-path

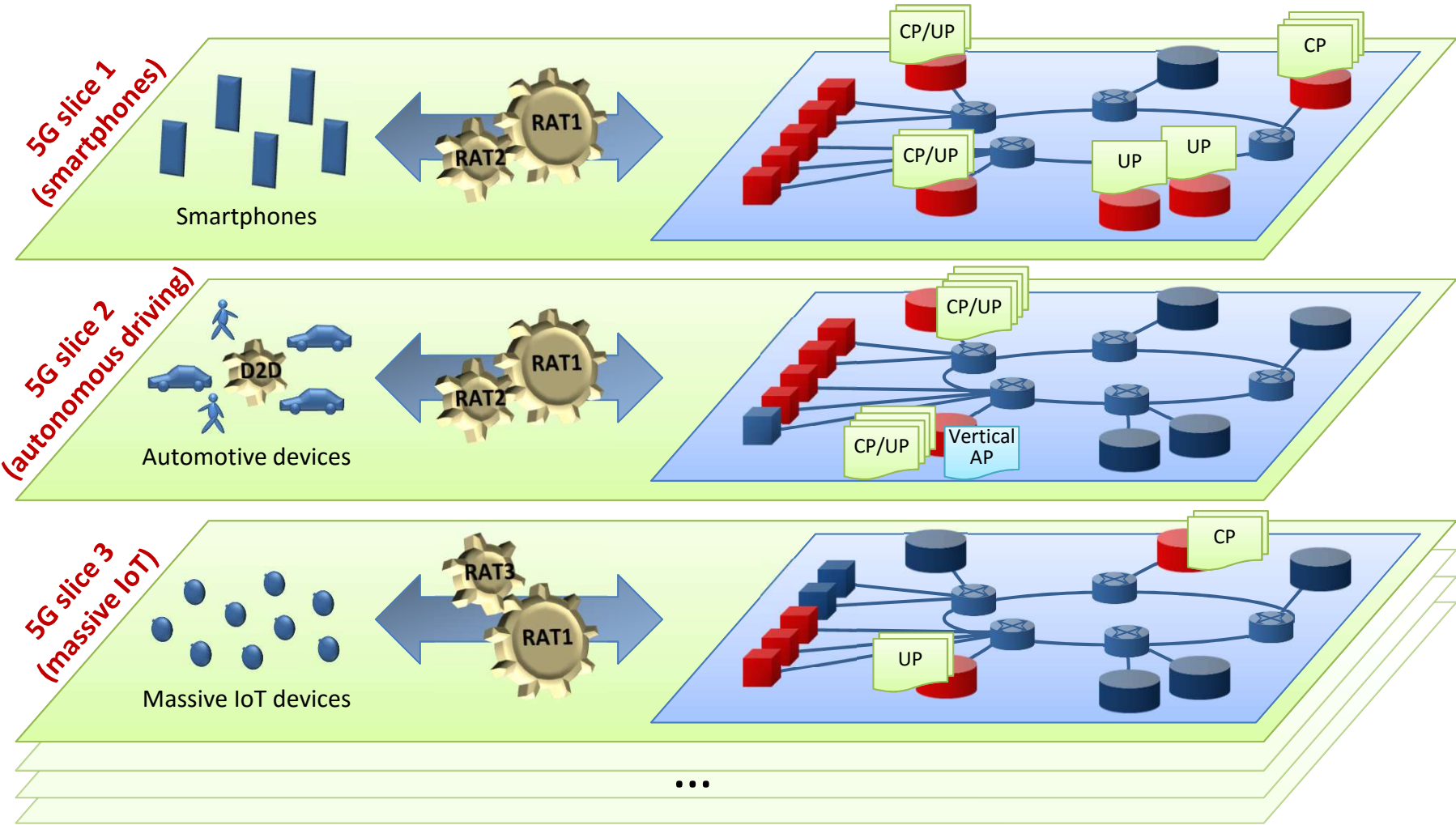


Data path consisting of hybrid multi-layer architecture

- Packet based: based on Crosshaul Common Frame (XCF)
- Optical Circuit: Used to alleviate congestion and for time critical traffic, e.g., CPRI

Adaptation functions to transform among different technologies and XCF

5G Network Architecture (from NGMN)

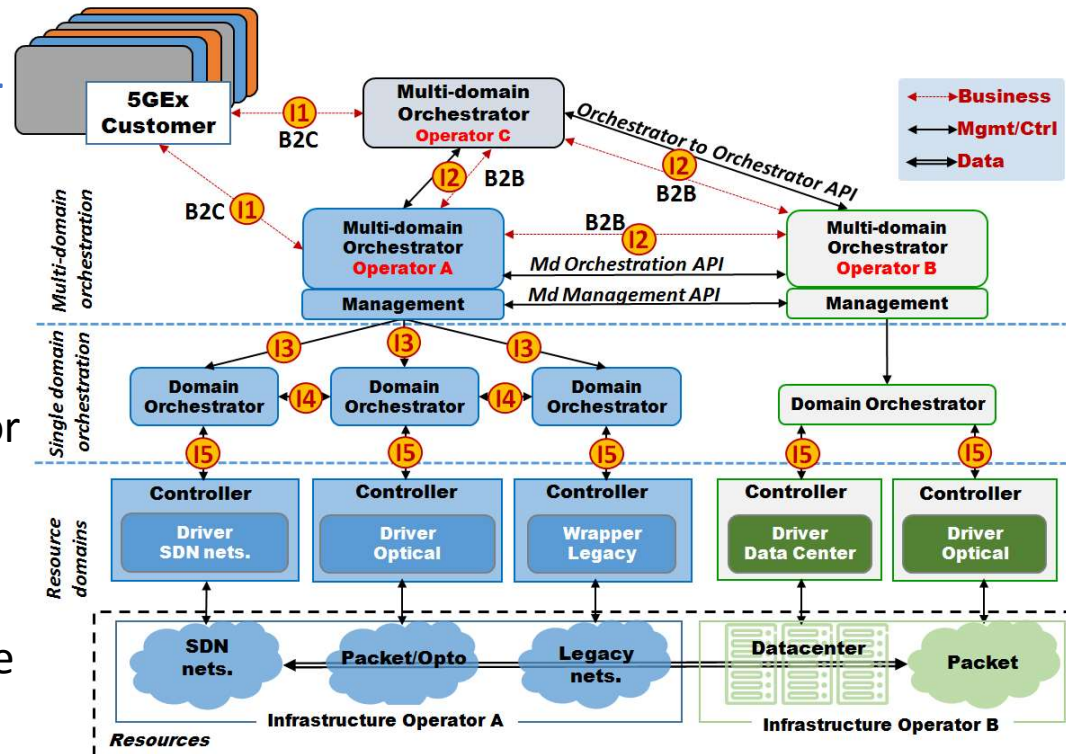


Taking action – 5GEx project⁽¹⁾



5GEx Mission:

- enable business and technical **cross-domain service orchestration** over multiple administrations,
- realize **composite services** by combining cross-domain network, computing and storage resources
- develop suitable **business models** for operators to optimally buy, sell, and integrate 5GEx services
- build and deploy a proof-of-concept **system prototype**, implementing the “Sandbox Exchange”



From dedicated physical networks with dedicated control and dedicated services and resources for different applications...



...to a “network factory” where resources and network functions are traded and provisioned: new infrastructures and services are “manufactured by SW”

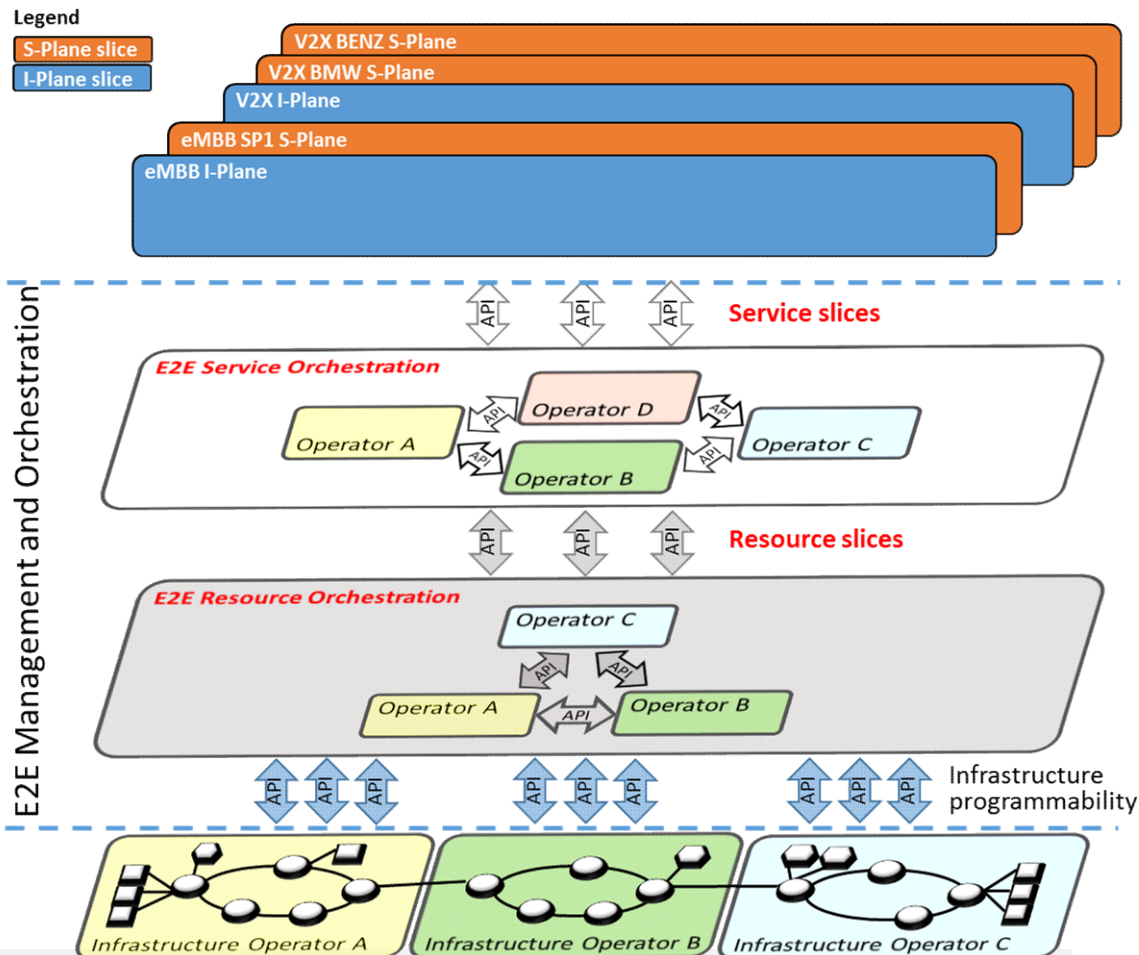
5GEx project

- Initial set of use cases categorized as follows:
 - Connectivity
 - Network as a Service
 - Network + Storage + Compute as a Service
- Incremental approach
- Emphasis on multi-domain

Partners include: Telenor, Deutsche Telekom, Telecom Italia, Orange, Telefónica, Ericsson, Huawei, HP, ATOS, BISDN, RedZinc, UCL, UC3M, AUEB, BME, KTH, MNS

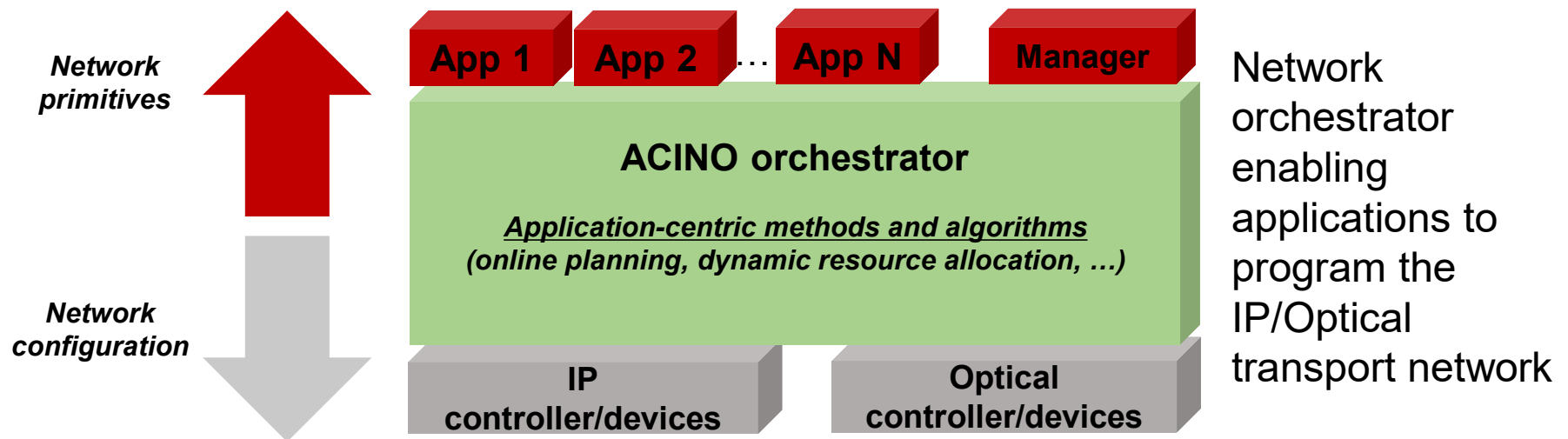
Main axis for innovation

- Multi-domain (in its multiple variants) not sufficiently addressed yet
- Business (end-service oriented) perspective (SLAs, billing, etc) not only technological feasibility (infrastructure oriented)
- Definition of future interconnection model and wholesale services around network APIs



ACINO (Application Centric IP/Optical networks)

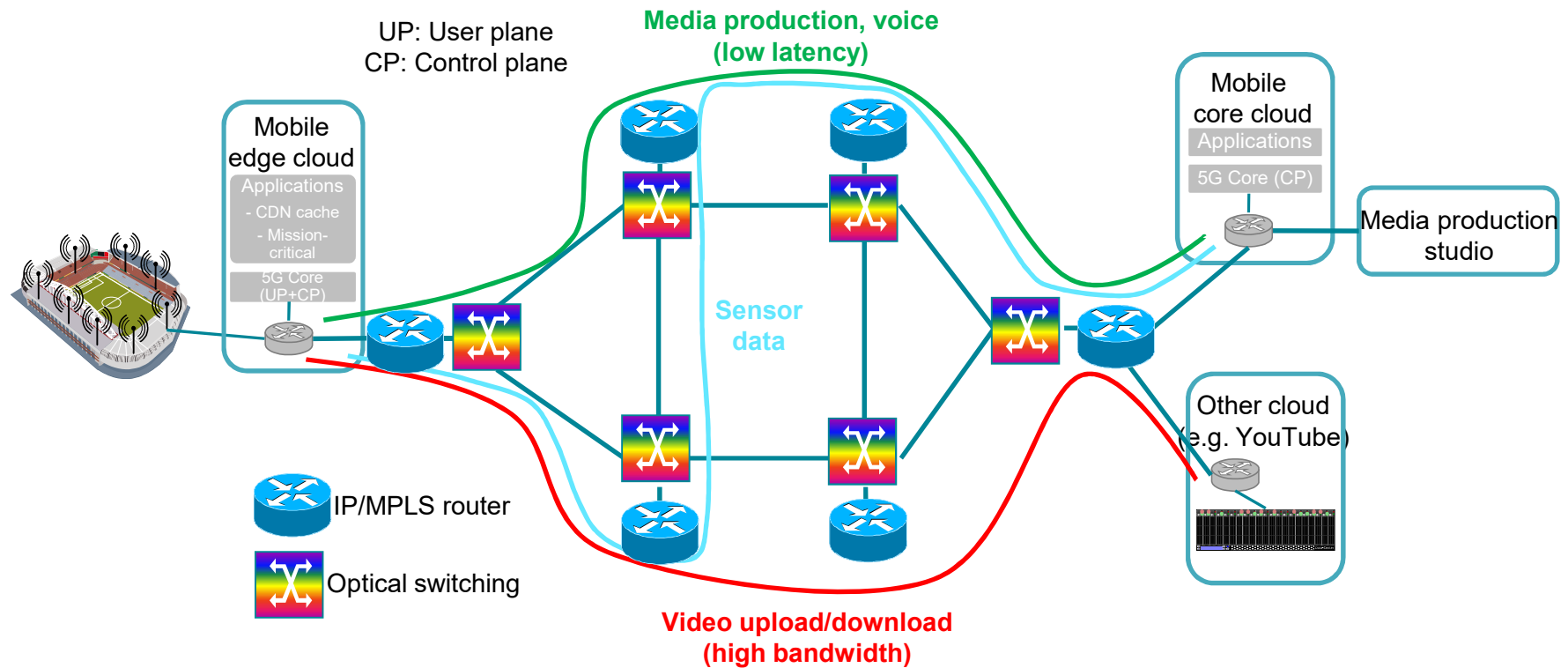
- Use Cases
 - Application-based Data Center Interconnection
 - Enabling dynamic 5G services
 - Application-specific protection strategies
 - Secure Transmission as a Service
 - Dynamic Virtual CDN deployment
 - Application-centric in-operation network planning



Partners include: Telefónica, Acreo, Create-Net, ADVA, Sedona, AIT

Company name

Per-application behaviour

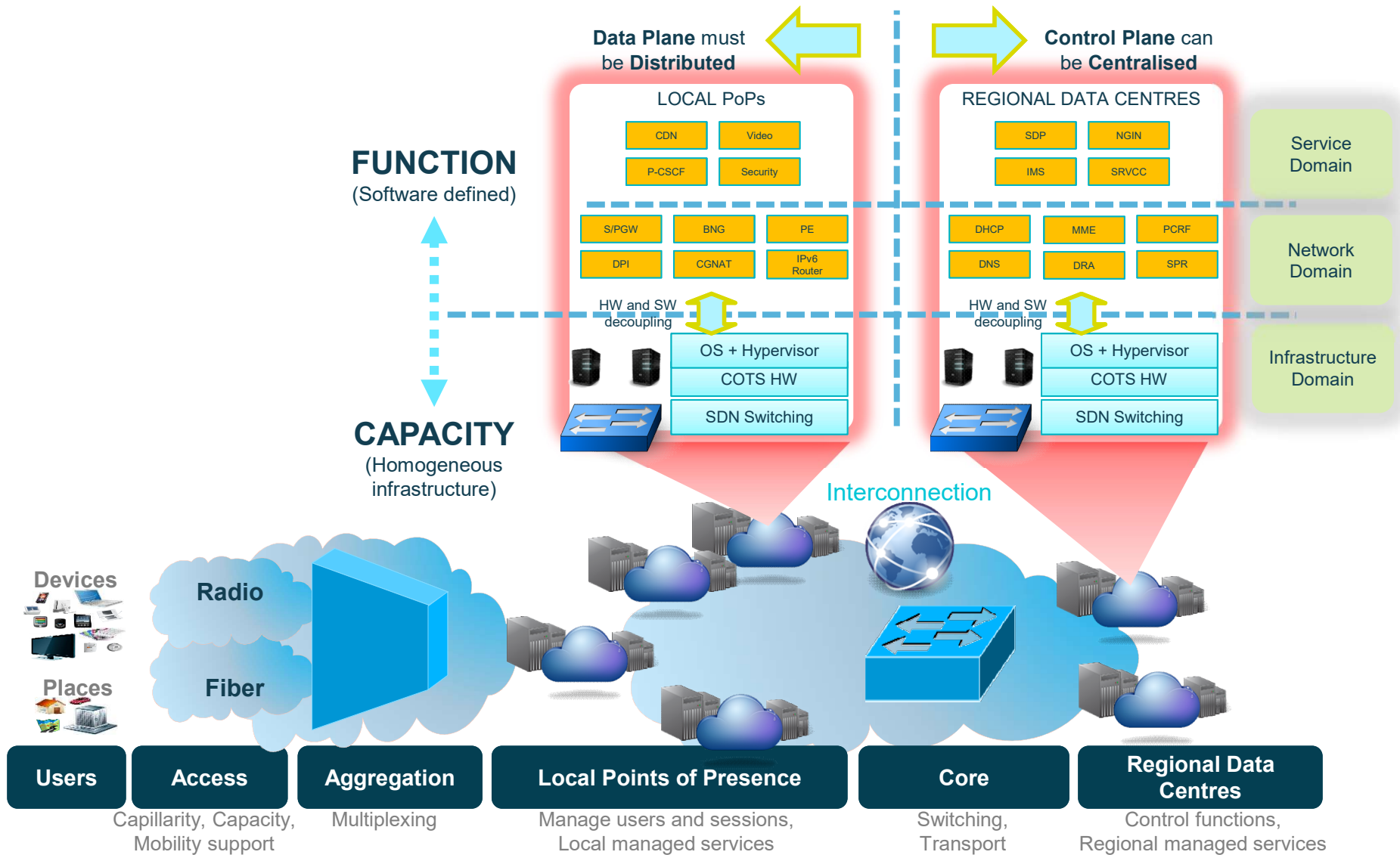


The three applications take different paths through the network

04 

Conclusions

The Future Scenario



Conclusions

- E2E SDN enables automated and simplified network service provisioning through different network segments (metro, core, data center...) and technologies (IP/MPLS, optical, MW, OpenFlow...)
- Such automation and simplification could be achieved by applying two complementary actions:
 - Minimization of network configuration points by transferring multidomain and multilayer provisioning functionalities from NMS to the control plane.
 - Unified network configuration and orchestration mechanisms enabling end to end network provisioning according to service and network optimization criteria.
- Common information modelling among vendors is a must

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