# optical networking topics of importance for 5G

5GPPP Research and Innovation Priorities

- Optical Networks-

"vision from the optical stakeholder group"

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# Motivation for Optical Networking in 5G*

- Moving to a **Cloud-centric world**; **Ample, flexible and low latency connectivity** to the user, inside data centers and between distributed sites is becoming the bottleneck which undisputedly **only optical networks** can resolve
- **Availability**, and **performance** of **network infrastructure** is also crucial
- **Evolution of the cloud infrastructure and services will have to rely on optical infrastructures**



* inputs from 5G Optical Stakeholders group towards 5G PPP Research and innovations priorities

# Key figures on Optical Networking

- **Europe** has been at the **forefront of optical networks R&D** >25 years
- **7 of the top 20** network operators HQ are in Europe
- **6 of the 20** largest optical equipment manufacturers have their main R&D centers in Europe
- **3 of the top 5** optical component manufacturers have operations in Europe.
- **Europe has a leading industrial and academic** base focusing on **high-performance, high capacity optical networking solutions** leveraging a 350 B$ telecommunications infrastructure market and **impacting more than 700,000 jobs in Europe**[2].
- Strong position in metro & core networks **(>25% market share,10% CAGR*)**
- **Data center and access/aggregation networks** represent **opportunities for further growth**, if Europe is prepared to invest.



* Compound Annual Growth Rate

# Consolidated targets

- *A **research priority:***
  - *focus on **Petabit/s energy efficient optical core and metro networks** leveraging advances in photonics devices, new fibers and multiplexing schemes, digital signal processing and system design including new **advances in transport SDN and NFV***
- *An **innovation priority:***
  - *focus on delivering **next generation network technologies** for **optical access and aggregation** targeting **optimized convergence between fixed and mobile** as well as programmable **orchestration of network and IT resources***

*(i.e. managed delivery of 10Gbps per user over thousands of users per system relying on advances on photonics access technologies on low cost transceivers, photonics integrated circuits, and low cost devices for wavelength manipulation)*

# RTD challenges I

- ***Programmable optical backbone networks supporting petabit throughput***
  - Rapid growth of user demand for increased connectivity, mobility and bandwidth. Actions should cover new spectrally efficient, adaptive transmission, networking, control and management approaches to increase network capacity by a factor of 10 while at the same time reducing power consumption, footprint and cost per bit and maintaining reach.

- ***Disruptive approaches for increasing network capacity***
  - Employ new fiber types (e.g. few mode, multi-core or photonic band-gap fibers) and mandate a completely new network infrastructure as consequence. Investigate new network and system architectures along with optical link engineering, switching, and migration aspects.

- ***Trans-layer coordination for elastic optical networks***
  - Increased optical layer flexibility enables a self-adaptation of the transport network to higher layer traffic and introduces a new dimension in network optimisation. Investigate/define mechanisms for layer interaction, and derive energy-efficient network and node architectures including their aggregation, switching and transport functions.

# RTD challenges II

- ***Optical network virtualisation, transport SDN and network functions virtualisation***
  - High-performance network-based applications impose stringent QoS restrictions requiring dedicated networks. Actions should cover scalable virtualisation strategies of both the optical infrastructure and operator's equipment in a flexible and open way, facilitating a seamless federation of network and IT resources. SDN should be enabled at the optical layer for application specific network slicing at optical layer, coordination and orchestration of higher network layers and applications with the optical layer.

- ***Unified control of optical access, metro and core network segments and wireless technologies***
  - The planning and design of both mobile and optical networks have evolved independently, leading to a complete functional and physical separation of optical access/aggregation and wireless infrastructures. The principles of SDN should be applied to the coordination of the optical access, aggregation and core network segments as well as the orchestration of optical and wireless technologies. Actions should investigate a common infrastructure and set of unified control functions to optimize locations of network elements to save both CAPEX and OPEX, reduce energy consumption and to enable the share of network resources in a multi-operator and multi-vendor scenario

# Innovation challenges

- ***New approaches for converged optical access networks***
  - Ever increasing bandwidths in optical and radio access networks require lowest-cost and lowest-energy transmission as well as centralization of all relevant network functions. Actions should cover cloud-centric network architectures along with adapted optical access systems capable of consolidating broadband access, business access, backhaul and fronthaul with a single platform.
- ***Optical network technologies for ubiquitous 5G access***
  - Access networks will have to dramatically grow in user capacity, quality of service, responsiveness, energy efficiency and number of connected devices while keeping a sustainable cost. Leveraging novel integrated photonic devices and subsystems, actions should cover new optical transmission and switching techniques as well as new network concepts and control architectures.

# Comments and suggestions

- Optical networking technologies need to evolve together with 5G PPP
- 5G needs to strength transport SDN with its capabilities and services
- ONF has very  deep discussions in transport SDN, and how we make our network technologies agnostic. We need to strength EU involvement
- We need to deal with converged scenarios (i.e. 4G outside and fibre inside home, we can not decouple it) and its impact on energy efficiency too
- It is needed to strength the importance of improving resiliency, performance at the infrastructure level (microwaves are less stable)
- We are evolving to a service society and we will depend on infrastructure reliability and stability (i.e. large roll out of e-health system will require much higher reliability of the  infrastructure)
- Users services will only evolve if core networks are evolving to cover the expected growth. It is not just a question of capacity, there are many other issues behnd.

# New projects within the CaON

- **ACINO** - Application centric IP/Optical network orchestration
  - Optical networks become more elastic and may allow finer granularity optical services in a cost effective manner (i.e. sliceable transponders). It will deliver an open source IP/optical orchestrate suite.
- **SAFARI** (EU-Japan) Reconfigurable infraestructura control
- **Orchestra** - Optical performance monitoring enabling dynamic networks using holistic cross-layer self-configurable truly flexible approach
- **ROAM** - Revolutionising optical fibre transmissions and networking using the orbital angular momentum of light
  - New device to support orbital angular momentum. Increase connectivity in DCs more than 100 times
- **Nephele** - E2E scalable and dynamically reconfigurable optical architecture for applications aware SDN cloud
  - Develop a fully functional control plane overly comprising an SDN controller
- **iCrrus** - Intelligent converged network consolidating radio and optical access around user equipment

# Current projects

## COSIGN

- Implement a flat, scalable DCN architecture empowered by optical technologies and SDN based network
- Goal 1: change the TOR (Top of Rack) switch to support more upload connections, full mesh, enable mixture of technology,..
- Goal 2: optical switching in the DCN to scale above # of uplink connection in ToR switch. Multiple topologies under investigation for handling different type of traffic and services
- Goal 3: integrate the new components and the architecture into a common resource control framework

## STRAUSS:

- A general controller dealing with GMPLS and OF. Optical Network Virtualisation (with QoS and SLA specific requirements)
- Multidomain transport networks
- Phase 1: Adaptation (Single SDN controller)
- Phase 2: Peer Coordination (Multiple SDN controllers)
- Phase 3: Hierarchical orchestration (Single SDN controller)

## INSPACE:

- Spatial spectral flexible optical networking. Enabling solutions for a simplified and efficient SDM
- Define an additional switching level. Design multi-dimensional resource allocation algorithms and study required control extensions, and study its benefits.
- 3 degrees of flexibility Modes/core, Wavelengths, Data rate.

# Example of impact in 5G
# Project STRAUSS (http://www.ict-strauss.eu/)

## Project content related to 5G

- Highly integrated and scalable software defined optical transceivers supporting bandwidth variable multi-flows for flexible Ethernet transmission based on OFDM and DMT.
- Flexi-grid DWDM optical circuit switching node architectures for long haul transport.
- Cost/energy efficient and extremely fast-performing switching node architectures based on variable-capacity and fixed-length optical packet switching technology for access and aggregation networks, and OPS/OCS integrated interface.
- Requirement and functional specification and implementation of a virtualization layer based on the concept of virtual network controller for multi-domain and multi-layer transport networks
- Definition and implementation of a feature-complete SDN control plane targeting single and multi-layer optical networks.
- Architectural design, function, interface specification of a network orchestrator for the interworking and coordination of heterogeneous control planes (e.g., GMPLS/PCE and SDN/OpenFlow) and transport technologies in mult-domain networks to offer end-to-end Ethernet transport services.
- Specification of a common control orchestration protocol (orchestrator southbound API) to allow interfacing with the control plane instances regardless of the employed control technology (GMPLS or OpenFlow controller).

## How it expects to impact 5G?

- Cost/energy efficient, ultra-high bandwidth, ultra-low latency and programmable transport architectures for 5G core network and backhaul.
- Dynamic and on-demand partitioning of multi-domain and multi-layer transport infrastructure to offer dedicated virtual transport networks to deal with the specific QoS and SLA of 5G services.
- End-to-end provisioning services across multiple domains with heterogeneous transport and control plane technologies to provide dynamic connectivity between 5G RANs and distributed data centers in order to enable VNF service chaining.