PHOTONICS PUBLIC PRIVATE PARTNERSHIP


***Optical Circuit switched Time sensitive network architecture for high-speed Passive optical networks and next generation Ultra-dynamic & reconfigurable central office environmentS - OCTAPUS***

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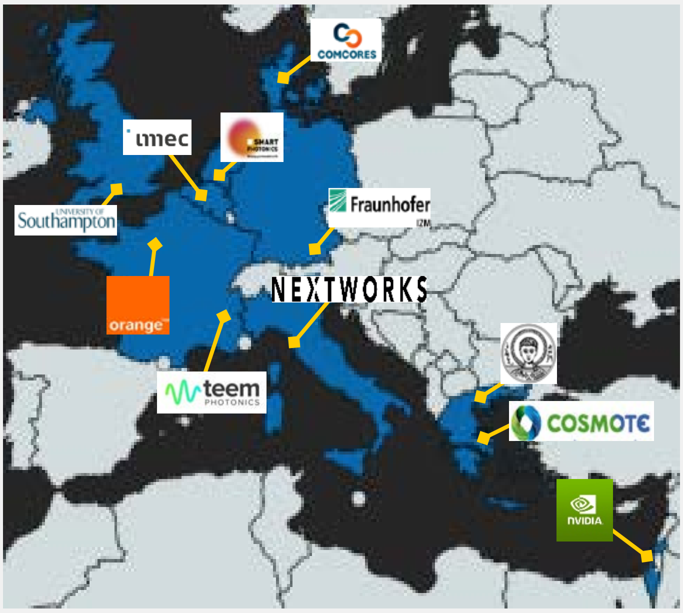
| Coordinator | Aristotle University of Thessaloniki, GR |
| Contact | **Prof. Nikolaos Pleros**<br>email: npleros@csd.auth.gr<br>**Dr. Chris Vagionas**<br>email: chvagion@csd.auth.gr<br>**Dr. Marios Gatzianas**<br>email: mgkatzia@csd.auth.gr |
| Website | http://www.octapus-ict.eu |




## THE CHALLENGE

The global demand for fixed and mobile bandwidth capacity has risen massively over the past years tirelessly fueled by a) the increasing popularity of Over-The-Top (OTT) video streaming services following a steep growth curve expected to reach 21% Compound Annual Growth Rate (CAGR) until 2028 and b) the rise of Machine-to-Machine communications predicted to account for a hefty 50% of the global connected devices by 2023. On top of the skyrocketing capacity demands, emerging 5G and industrial internet applications, classified under the Ultra-Reliable and Low Latency Communications (URLLC) category, are currently posing a new strict latency-oriented framework severely challenging 5G infrastructure and calling urgently for new radical architectural changes directly at the key aggregation infrastructure being in local proximity to the subscribers: the Central Offices (COs). This capacity-latency predicament underlines the need for the employment of innovative technological solutions, with photonics emerging as the key enabling technology**,** that will establish a new Next Generation CO (NGCO) ecosystem where component-level advancements can yield unparallel architectural benefits**.**

## MISSION STATEMENT

**OCTAPUS** will launch an agile, low-cost and energy-efficient Photonic Integrated Circuit (PIC) technology framework that will re-architect the NGCO ecosystem, transparently upgrading its capacity to 51.2Tb/s and beyond, through an innovative optically switched backplane and transceiver toolkit. To realize its ambitious goals, **OCTAPUS** will reap the benefits of the best-in-class material platforms and technologies, namely:

- the novel integration of antimony-based Phase Change Materials (PCM) on the low-loss and low-cost N-rich SiN for its switching components,
- the excellent optoelectronic properties of InP-based O-band optical components for its transceiver modules,
- the mature and low-cost Si CMOS process for its ultra-low power electronics, and
- the low loss and compact interfaces to fibers, through advanced glass-based interposers with integrated diplexer functionalities.

## PROJECT OBJECTIVES

**OCTAPUS** aims to deliver an agile, low-cost and energy efficient PIC technology framework that will re-architect the NGCO ecosystem, transparently upgrading its capacity to 51.2Tb/s and beyond, through an innovative optically switched backplane and transceiver toolkit. To achieve its mission, **OCTAPUS** targets the following objectives:

i) to deploy novel non-volatile antimony (Sb) phase change materials (PCMs) to develop a range of zero-power and ultra-low loss SiN-based electro-refractive switches, featuring ns-scale reconfigurability with 2 orders of magnitude lower losses compared to conventional Ge-Sb-Te PCMs,

ii) to develop an energy- and cost-efficient O-band 50GHz component and I/O portfolio and demonstrate up-to 800Gb/s optical transceiver engines for board-to-board and long-reach PON communication with an impressive 4× and 8× energy consumption improvement against respective state-of-the-art solutions and up to 37.5% cost reduction,

iii) to deploy a pool of advanced optical components to demonstrate a low-power and ultra-fast reconfigurable optically enabled backplane technology for NGCOs,

iv) to exploit its optically enabled backplane technology to architect a low-energy, high-capacity, scalable and SDN-reconfigurable NGCO ecosystem offering deterministic service guarantees (TSN controlled) for time-sensitive traffic while providing reliable and ultra-low latency communications for telecom and industrial applications,

v) to demonstrate a scalable NGCO architecture with up-to 200Tb/s capacity and validate its advanced optical component technologies through a series of lab and field trials in time-sensitive applications scenarios.

## TARGET TECHNOLOGY BREAKTHROUGHS

**Zero-power switching fabric suite on SiN:** OCTAPUS will migrate from the mainstream non-volatile GST-based phase change materials towards novel antimony (Sb) compounds integrated on N-rich SiN platform to deliver a complete suite of robust, zero-power, non-volatile and ultra-low loss electro-refractive 2x2 Mach-Zehnder Interferometric (MZI) switches for both O-band (extended to 8x8 and 16x16 optical circuit switch (OCS) Benes configurations) and C-band (1:16 tree switch configuration) providing ultra-low-loss backplane photonic links with 40ns reconfiguration time and improving co-integration for back-end of-the-line compatibility with electronics.

**Monolithic InP platform for cost-effective and energy efficient TxRx components:** OCTAPUS aims to exploit O-band InP generic foundry to offer a complete top performance photonic components' kit for the 50Gb/s transceiver of its NGCO ecosystem. More specifically, OCTAPUS' photonic and electronic toolkit will offer two different types of O-band transceivers, i.e., (i) A 800Gb/s (16×50Gb/s OOK) ultra-low-power intra-NGCO Optical Transceiver engine, and (ii) a 16 channel HS-PON Optical Transceiver engine with 800Gb/s aggregate bandwidth synergizing with tailor-made low-power 50Gb/s electronic driving and receiver circuits.

**Low-loss O-band Spot-Size Converters (SSCs)**: Within OCTAPUS, a new O-band SSC will be developed realizing for the first time a low-loss optical coupling interface between InP and glass-based waveguides.

**Low-loss multiband glass-based diplexer minimizing PIC-fiber interconnect coupling losses:** OCTAPUS aims to develop novel glass-based multiband 1340/1550nm optical diplexer arrays embedded on the same chip with the glass-based Waveguide Array to Fiber Transposers (WAFT) solution to achieve record coupling efficiency between optical fiber arrays and the high-confinement PICs based on SiN and InP in a packaging-ready footprint. The novel glass diplexer -interposer module will collect and multiplex light signals from the PICs before feeding them into optical fibers.

**Introduce a novel, reconfigurable and ultra-fast optics-enabled NGCO network with deterministic latency guarantees:** OCTAPUS aims to leverage its cost-and energy efficient photonics platform towards architecting a novel NGCO ecosystem facilitating a transparent capacity upgrade to 51.2Tb/s and accommodating 3 different levels of latency-based traffic provisioning, fully aligned with the increased CO capacity demands and the respective URLLC latency-related requirements. OCTAPUS' backplane will be enriched with an SDN-enabled controller to ensure interoperability and seamless operation with the rest of the system. Moreover, the use of Ethernet-based TSN-enabled hardware and corresponding TSN network controller is mandated by OCTAPUS's flexible switching layout, which offers low-latency through frame prioritization/preemption and scheduling among traffic classes. To this end OCTAPUS will design and build a 50 Gbps FPGA-based TSN Ethernet implementation, for compatibility with the 50G optical transceivers of UL switches and IF cards.

To highlight the radical innovations of its technology toolkit,OCTAPUS will develop the following prototypes:

i. An SDN-controllable 16×16 optically switched backplane,
ii. a TSN-enabled uplink switch prototype interfaced to a PCB-packaged 800G (16×50Gb/s) low-power optical engine for *backplane* communication,
iii. a TSN-enabled IF-card prototype interfaced to an 800G *backplane* optical engine and an 800G long-reach optical engine for communication with 16×50G-PON endpoints.

An extensive set of lab trials will also take place to validate the developed switching components and transceiver modules within the OCTAPUS architecture, as well as the integration of the hardware with the developed SDN and TSN controllers. A final field trial demonstration will validate the NGCO's proper functionality and achievement of required KPIs in production-scale TSN-enabled Fronthaul and URLLC services over an MNO's network.

## PARTICIPANT ORGANIZATIONS & PRINCIPAL INVESTIGATORS

| a/a | Participant Organization | Abbreviation | Principal Investigator |
|---|---|---|---|
| 1 | Aristotle University of Thessaloniki - GR | AUTH | **Nikos Pleros** (npleros@csd.auth.gr) |
| 2 | NEXTWORKS - IT | NXW | **Nicola Ciulli** (n.ciulli@nextworks.it ) |
| 3 | TEEM Photonics SA - FR | TEEM | **Adrien Billat** (a.billat@teemphotonics.com ) |
| 4 | Cosmote Kinites Tilepikoinonies AE - GR | COSM | **George Lyberopoulos** (gliberop@cosmote.gr) |
| 5 | Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung EV - DE | Fraunhofer | **Tolga Tekin** (Tolga.Tekin@izm.fraunhofer.de) |
| 6 | NVIDIA Computer Hardware Manufacturing - IL | NVIDIA | **Elad Mentovich** (mentovich@nvidia.com) |
| 7 | SMART PHOTONICS BV - NL | SMART | **Ruud Vullers** (Ruud.Vullers@smartphotonics.nl) |
| 8 | Interuniversitair Micro-Electronica Centrum - BE | IMEC | **Peter Ossieur** (peter.ossieur@imec.be) |
| 9 | ORANGE SA - FR | ORAN | **Fabienne Saliou** (fabienne.saliou@orange.com) |
| 10 | COMCORES APS - DK | COMC | **John Illerup Mortensen** (john.mortensen@comcores.com) |
| 11 | University Of Southampton - UK | SOTON | **Frederic Gardes** (f.gardes@soton.ac.uk) |