Newsletter #2 August 2023

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A lightweight software stack and synergetic metaorchestration framework for the next generation compute continuum

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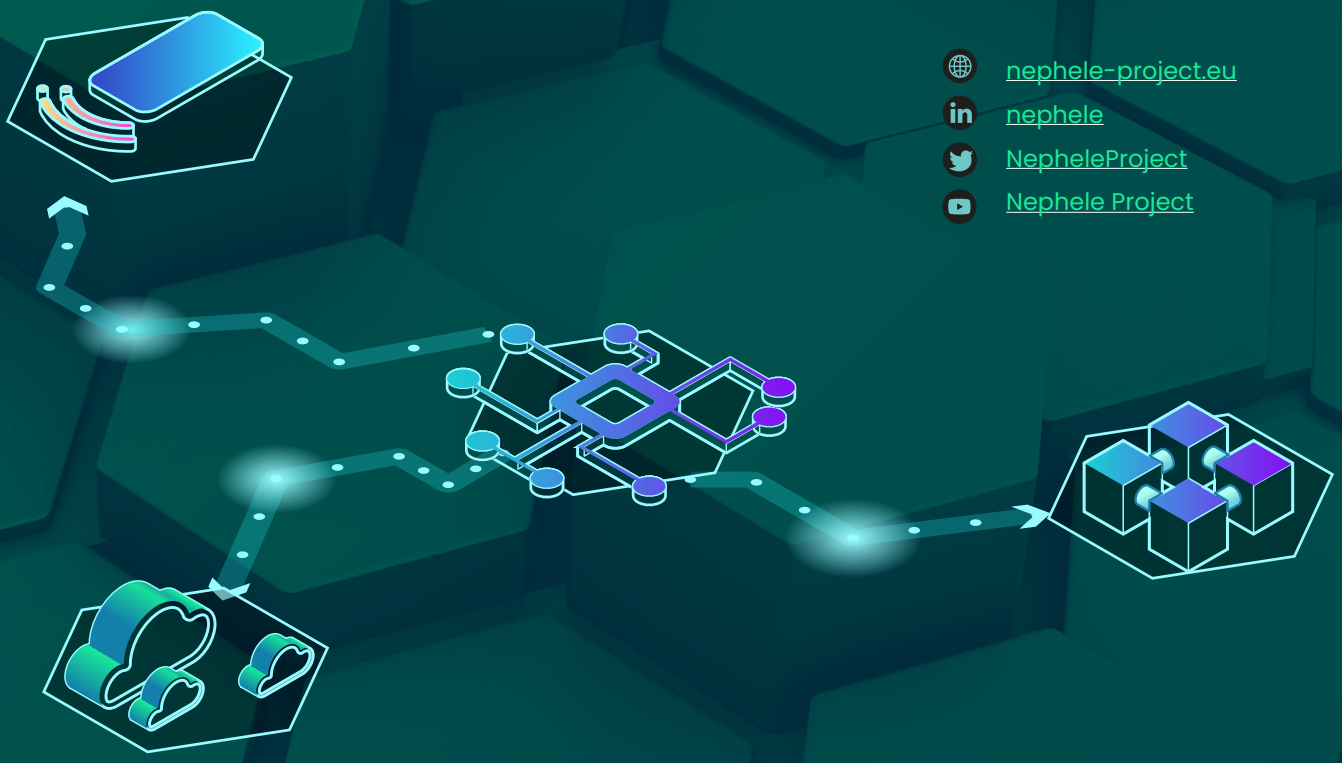

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NepheleProject
Nephele Project

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101017111.

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Project progress

Requirements, Reference Architecture and Use Cases

IoT Devices Management, Virtualization and Ad-hoc Clouds Formulation Requirements

The consortium identified and analysed requirements related to the management of ad-hoc clouds and the communication of IoT devices with VOs, based on TSN and SDN principles. The partners have actively participated in the definition of the project requirements with special attention to the security aspects to enhance interoperability and alignment with communications and security standards.

Based on the existing technology brought to the project, as well as based on Use Case 2 (UC2) specific requirements, further identification and specification of the requirements have been prepared and proposed within the task - mainly aiming at integrating existing components to the NEPHELE framework and aiming for UC2 to benefit from the framework.

Synergetic Orchestration Requirements

The descriptions for the overall Synergetic Meta-Orchestration (SMO) platform and its internal managers have been elaborated as well as the identification of the different stakeholders participating in the platform and their objectives as a way to provide a first view of the storyline behind the SMO and the requirements needed to achieve their objectives.

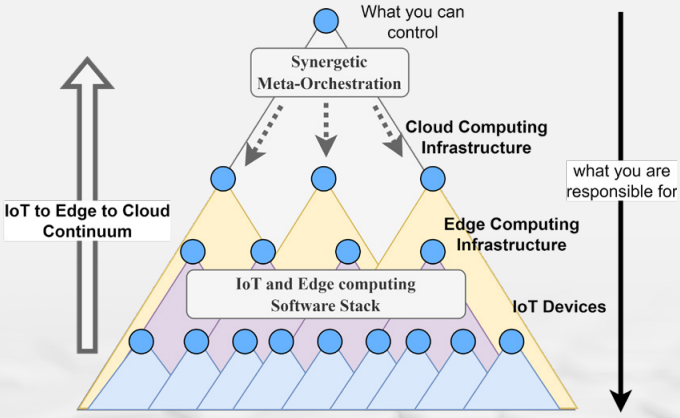
The identification and description of functional and non-functional requirements has been mapped to the corresponding SMO component along with their prioritization which will serve as a baseline for their development in successive WPs. Coordination and interoperability among the SMO platform components have been explored to achieve semi-autonomous management by creating a system-of-system architecture which relies on distributed intelligence and multi-layer intent-based orchestration mechanisms.

A series of development, testing and delivery patterns based on modern CICD principles for the SMO platform components have been explored and documented which will ensure that the platform is delivered to a high standard.

Use Cases Specification and Data Processing Requirements

The consortium identified and analysed requirements for IoT-VO-App communication, traffic prioritisation, and VO deployment on IoT gateways, and further investigated the suitability of simulation environments (e.g., SUMO) and tools for the needs of UC2. In addition, partners investigated technical requirements for the preparation of its infrastructure for UC2.

In addition, various partners have been in charge of the definition of stakeholders, locations, challenges, requirements, application examples and initial definition of the necessary components. The various UC participants specified initial application graph considering end-to-end use case scenarios.



Reference Architecture and Technology Watch

The initial reference architecture of the NEPHELE meta-orchestration ecosystem has been defined. Consortium members specified an initial TSN architecture and also elaborated on workflows for SDN-like management of ad-hoc clouds. Partners have

also actively participated in the definition of the project requirements contributing to the architecture definition, with special attention to the security aspects and with the aim of enhancing interoperability and alignment with communications and security standards and with the need of energy management and smart building verticals. In addition, E2E diagrams for the architecture of the platform were defined, whereas partners contributed to technology watch with Eclipse IoT&Edge projects, such as Eclipse Zenoh.

Virtual Object Stack Development

Intelligent IoT Devices Modelling, Management and Interoperability

The consortium conducted an early investigation of technology specific southbound interfaces for IoT network configuration control, including a first representation of the IoT topology at the VO level. Certain partners focused on security management and interoperability at VO and IoT levels, advancing in the definition of the interfaces of the security components and the requirements of the services and devices, to provide security by design and the necessary mechanisms to preserve privacy in data exchanges with constrained IoT devices. In addition, various discussions were held to identify gaps in current Web of Things standards and gather input on needs to exploit advances in work on linked data, decentralised identifiers and verifiable credentials.

Autonomic Functionalities and Ad-hoc Clouds Management

The consortium investigated the existing scheduling mechanisms for TSN, as well as control-plane approaches for the configuration of TSN schedules. TAPRIO and Centralized Network Control (CNC) have been considered as appropriate for the needs of NEPHELE, whereas NETCONF is under consideration for the interaction between the TSN bridge (e.g., realized within IoT gateways) and its control plane.

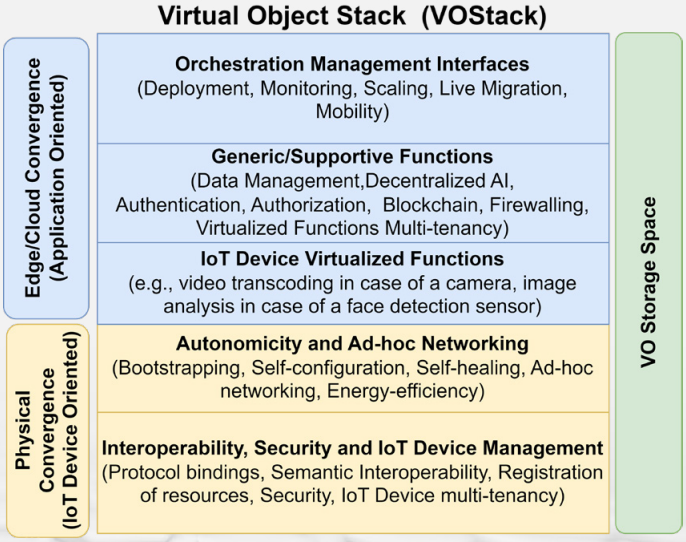
In terms of SDN, the consortium examined the various requirements and investigated traditional ad-hoc routing protocols, as well as SDN approaches for path computation over ad-hoc clouds. The consortium adopted an SDN-like control approach, which will enable the configuration of ad-hoc routing protocols using a centralized controller. Control-plane functionalities for both TSN and SDN will reside proximate to the managed IoT devices and potentially within VOs, as part of the VO stack.

IoT Device Virtualized and Supportive Functions

NEPHELE partners have developed virtualized control plane functions (e.g., CNC) for TSN datapaths. Additional work targeted security and interoperability functions for the definition of things at the VOStack level, supporting standard mechanisms such as NGSI-LD among others. VO and cVO Stack proof-of-concept has been designed - the blueprint includes an IoT Gateway and multiple IoT sensors supported by virtualized/supportive functions such as video stream selection, configuring sensors sampling rate, converting sensors' measurement units, etc.

Orchestration Management Interfaces

Orchestration management interfaces for the VOs and cVOs have been defined and implemented, enabling the development of distributed applications that support interlinking of edge/cloud application components with VOs and cVOS. Basic



orchestration actions over VOs and cVOs have been also defined.

Intelligence on IoT Devices and interplay with VOs

The consortium studied the W3C Web of Thing Description (TD) standard and the state-of-art of Machine Learning techniques, customized for constrained IoT devices (TinyML) in order to evaluate how to implement these mechanisms in IoT devices, such as the IoT connector.

Edge and Cloud Computing Synergetic Meta-Orchestration

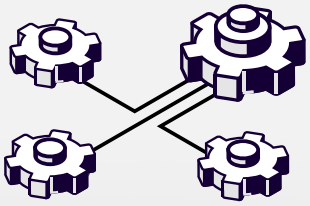
Hyper-distributed Applications Development Environment and Repository

This task has been focused on analysing the initial proposals of the VOs from different partners and the identification of the technologies that will be used to create the Repository.

Partners worked on the NEPHELE repository design: specifications for the type of descriptors to be stored and managed, image repositories, and interfaces for interaction with the deployment mechanisms. They also reviewed the state-of-the-art of repositories and technologies that would be aligned with the needs of the UCs and SMO platform and kicked-off the design and development of PoC. Certain requirements were specified in scope of the task's topic and planning initial steps towards the adaptation of a network slice provisioning and management provided by the cloud-native 5G system via NFV-based orchestration using Kubernetes and Helm charts.

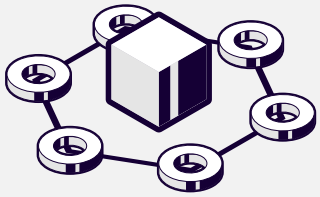
Federated Compute Resources Management

The target clustering platforms that will be considered in this project were identified with a focus on Kubernetes clusters. The work was also oriented to identify the environment of interest used for telco networks integration, as well as possible interfaces with the top-level synergetic orchestrator.



In parallel, a review of the state of the art was also done to identify the existing tools in the space of workloads placement at the edge, resources monitoring and management, as well as inter-cluster communication and collaboration to enable hyper-distributed applications deployment on the NEPHELE platform. Open Horizon was identified as the tool of choice for workload placement, while a number of other open-source projects that enable inter-cluster communications like LIQO and SKUPPER were explored. The consortium opted for a top-down approach and progress has been made for the definition of intents to express the different service requirements and the SLA. These intents will then be translated to lower level scheduling instruction and network primitives. Early sketches and design of the high-level architectural diagrams were also produced.

Compute Continuum Network Management



Compute Continuum Network Management is mainly devoted to the introduction of the CNIT NFVCL and its adaptation to be included in the design of the network manager.

Partners examined the basic APIs that must be supported for the interaction of the compute resources manager with the network manager, considering an intent-based approach. They have also investigated solutions based on SDN and the programming language P4 for fine-grained network management.

AI-assisted Synergetic Orchestration

AI methods (e.g., reinforcement learning) were investigated for the optimized partitioning of application graphs across multiple clusters. Initial steps have been made towards an intelligent framework for the translation of intents and high-level requirements into low-level scheduling configuration (i.e., in relation to TSN). Additional aspects of synergetic orchestration were also studied, e.g., a 3D monitoring application, namely palindrome.js, should be seen as metrics or KPIs aggregation tool for various use cases, systems, or architectures. It could be deployed within the Virtual Objects (VOs) in NEPHELE architectures

as a single point of monitoring, which could later enable decentralized decisions.

Cybersecurity and Trust Management

This task is in charge of providing a secure and scalable resource access control solution for a highly dynamic and distributed edge/cloud scenario, enforcing domain-specific access control policies.

Among the task objectives is the use of standardized technologies and aligned with the strictest standards of security and preservation of privacy proposed by the European Union. For this reason, following the initial guidelines proposed the project for the definition of the architecture, this task seeks to match the cybersecurity and trust mechanisms with the W3C Web of Things specification. For this, the members of the task have been working on the fit of the Distributed Identifiers (DID) together with the use of self-sovereign credentials that allow a fine and user-centered control of the credentials, maximizing the protection of the data, to the while better protection mechanisms and more precise control are offered through distributed access control policies. These mechanisms are in turn supported by security protocols at the IoT level, such as CP-ABE, COAP or ACE-OAUTH, which are optimized for the needs of constrained devices. During this period, the work has been focused on analysing and studying the State of the Art of these technologies in the context of constrained IoT devices and with the aim of adapting them to the VO Stack. For the analysis it has been decided to consider two separate layers: a first layer between the limited IoT devices and the Virtual Object, and a second layer between the Virtual Object and the infrastructure, due to the different computing constraints and security requirements that are also being determined and analysing during the task work.

Open Call Management and Support Programme

The open call preparatory tasks have started during this period. The Selection Committee comprising technical partners have been constituted and the first meetings have taken place and are currently working on the production of the Open Call Package of Documents comprising, among others, the Call Announcement and Guide for Applicants (GfA) together with the Open Call Communication Strategy and Toolkit. The Committee is refining the technical aspects requested for launching the Open Call and soon they will validate the package of documents.

Dissemination, Communication and Exploitation

Dissemination Activities

This task is in charge of the definition of a concrete dissemination strategy and plan - and refining when needed along the project lifetime.

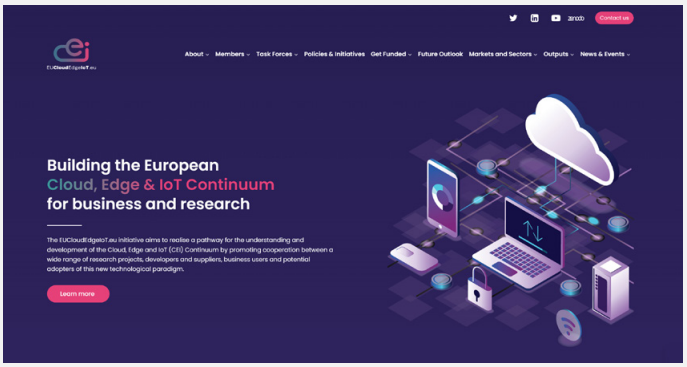
The first dissemination plan was defined, and KPIs to measure the impact of the dissemination plan have been stablished and are being monitored. During the last months, several partners participated to meetings and webinars to present the project use cases. One workshop proposal was prepared. One paper was published on the MDPI Future Internet journal related to Use Case 1, several conferences have been attended and one of NEPHELE conference papers has received the Best Paper Award in COMPSYS 2023. More information about the scientific dissemination

activities can be found in section "Past Events" of this newsletter.

NEPHELE partners have also been very active in meetings and events such as the workshop on open source in Toulouse (Jan 2023) or the Concertation and Consultation meeting in Brussels (May 2023) related to the task forces of the EuCloudEdgeIoT CSA.

Communication Activities

This task is in charge of the definition of a concrete promotion and communication strategy and plan, and also of the refining when needed along the project lifetime. This task is also producing communication and promotion material and feeding the communication channels and social networks with updates and news.



Promotional materials such as a project leaflet, posters and a rollup have been designed and are available to download from the website. The project website has been created and is being frequently updated with project news and information about events and publications. Social media accounts have been created in Twitter (now X) and LinkedIn, and the first video presentation have been uploaded to the project YouTube channel. KPIs to measure the impact of the website and social networks have been stablished and are being controlled periodically.

Liaisons with other H2020 projects are also being pursued. The project is regularly collaborating with the EUCloudEdgeIoT CSA activities. The website has included a section "Ecosystem" that includes information about the other MetaOS projects in the call and links to their websites and social networks.

Standardization Activities

The main objective of this task is to manage the contributions on behalf of NEPHELE towards standardisation bodies and working groups. Focus during the initial months of the project has been on identifying relevant standardisation bodies and working groups and monitoring project use cases and code discussions on the one hand, and standardisation discussions around linked data that could potentially impact the project. This included tracking ongoing work in W3C groups: Web of Things (W3C WoT WG), RDF-star, Verifiable credentials and Decentralized Identifiers, and monitoring discussions on the creation of a group scoped to standardise SOLID.

The consortium is interacting with W3C Web of Things standardization group to convey project requirements to the group and discuss strategy for implementation of Virtual Objects with this standard.

Exploitation, IPR Handling and Innovation Management

The objective of the task is to define and refine the exploitation strategy and individual partners' exploitation plans. Additionally, this task will ensure that the established rules for use of Intellectual Property Rights (IPR) are in use and coordinate all the activities related to the management of knowledge generated in the project.

An approach to market analysis and business plan has been presented and most suitable methods and metrics proposed. Intellectual Property, knowledge protection and regulatory issues have been also addressed. Initial input of background IPR items have been collected from the partners. Partners involved in use cases development have already started with identification of their specific vertical industries needs and positioning of their respective use cases and exploitable items within verticals addressed. Part of this work has been done within the EUCloudEdgeIoT.eu

platform/workshops where NEPHELE use cases' contributors have presented their findings, challenges, risks and issues.

Open Source Ecosystem, Community Building and Sustainability

This task is implementing the project open-source strategy and contributing to open European IoT-Edge-Cloud Continuum. This strategy will define licensing guidelines (inbound and outbound) and support the creation of an active community of developers and early adopters, including open call participants.

Initial steps have been made for creating a rich online community which includes end users that participate in the internal use cases innovators, developers contacted through the Open Call and all types of stakeholders interested in fostering the up-take of NEPHELE outcomes. The Online Community has been set up in FundingBox Platform. Stakeholders mapping is its definition phase. A digital campaign is being organised to widely advertise the Community within relevant domains in the EU. Content-related activities such as posts, events and interactive activities, such as Q&A, webinars, etc. are continuously being organised to keep users engaged with the community.

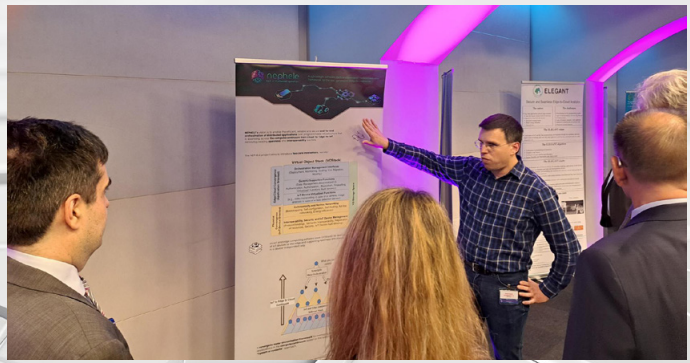
Highlights Of The Period

EC Concertation and Consultation meeting on Computing Continuum Event

This important meeting was organised by EUCloudEdgeIoT in The Claridge Hotel, Brussels, on 10-11 May 2023

Several EC representatives, including project officers and directors, attended the event. There was a "RIAs Guided Tour" session around the posters on the first day of the event, in which the EC representatives and other experts were guided across the project posters. A "RIAs Pitch Session" was also held, in which each project had the opportunity to briefly present its project goals, expectations and vision. And - last but not least - a "EUCEI Research Community Booklet" including relevant information about all the projects was made available for the event.

A NEPHELE presentation and a rollup were prepared for this event, and Anastasios Zafeiropoulos from NTUA represented our project.



NEPHELE 2nd Plenary Meeting

NEPHELE celebrated its 2nd Plenary Meeting at Inria premises in Lille on 16-17 May 2023. Several participants from this large team were also attending this meeting online.

The agenda was divided in two intense days with lots of very productive sessions to discuss the progress and next actions for all the active work packages. A lot of time was devoted to the Virtual Object Stack Development (WP3), NEPHELE synergetic meta-orchestration network development (WP4) and our four use cases (WP6).

An overview of considerations for the preparation of the first release of NEPHELE Platform (Dashboard and DevOps Environment Setup) was also presented. The consortium also devoted time to discuss dissemination and communication achievements and next strategies, preparation of NEPHELE first open call, exploitation plan, as well as standardisation and open-source software activities.

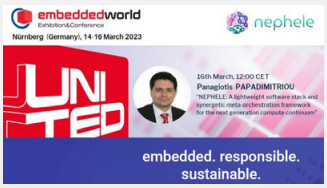
Past Events

MWC 2023

27 February - 2 March 2023, Barcelona, Spain

The Mobile World Congress (MWC) in Barcelona is the largest and most influential event for the connectivity ecosystem; global mobile operators, device manufacturers, technology providers, vendors, content owners and people interested in the future of tech come together under one roof. Tens of thousands of senior executives from the top global companies, international governments and trailblazing tech businesses converge at this event. Our colleagues from University of Macedonia represented NEPHELE on 2023 MWC.

Embedded World



14-16 March 2023, Nuremberg (Germany)

Embedded World Exhibition & Conference provides a global platform and a place to meet for the entire embedded community, including leading experts, key players and industry associations. Panagiotis Papadimitriou from University of Macedonia presented "NEPHELE: A lightweight software stack and synergetic metaorchestration framework for the next generation compute continuum" at the booth of Eclipse Foundation.

COMPSYS 2023

15-19 May 2023, St Petersburg, Florida, USA

The 2nd Workshop on Composable Systems (COMPSYS 2023) brings together the expertise of researchers and developers from academia and industry on all aspects of composable systems design, management and use. The paper "On the Implications of Heterogeneous Memory Tiering on Spark In-Memory Analytics" with acknowledgement to NEPHELE was accepted and presented in the framework of this event. Our colleague Dimosthenis Masouros (NTUA, Greece) was also invited there to pronounce the talk "Towards ML-drive in resource orchestration in disaggregated memory systems: challenges and opportunities".

IFIP Networking

12-15 June 2023, Barcelona, Spain

The paper "Towards the Integration of TAPRIO-based Scheduling with Centralized TSN Control" by George Papathanail, Lefteris Mamatas and Panagiotis Papadimitriou, from University of Macedonia, and with acknowledgement to NEPHELE, was accepted and presented at the 3rd International Workshop on Time-Sensitive and Deterministic Networking (TENSOR 2023). Besides the paper presentation, Panagiotis Papadimitriou co-chaired TENSOR 2023, which was held with with high attendance and a lot of discussions stimulated by the various talks.

DCOSS-IoT 2023

19-23 June 2023, Coral Bay, Cyprus

Two NEPHELE papers were accepted at the IEEE 19th Annual International Conference on Distributed Computing in Smart Systems and the Internet of Things (DCOSS-IoT 2023). This conference covered several aspects of distributed computing in smart systems - high level abstractions and models, systematic design methodologies, signal and information processing, algorithms, analysis and applications.

IEEE Cloud 2023

2-7 July 2023, Chicago, Illinois, USA

The paper IRIS: Interference and Resource Aware Predictive Orchestration for ML Inference Serving with acknowledgment to the NEPHELE project was presented online at the IEEE International Conference on Cloud Computing (IEEE Cloud 2023) by Aggelos Ferikoglou from National Technical University of Athens and received the Best Paper Award of the event. Do not miss the video recording of his presentation!

ETSI IoT Conference

4-6July 2023, Sophia Antipolis, France

The ETSI IoT Conference, in the framework of the ETSI IoT Week, offered attendees the opportunity to learn and share experiences related to IoT technologies, services, activities, requirements, looking at present and future standardization work. The 2023

edition included IoT demonstrations and offered keynote speeches, presentations, interactive panels, IoT demonstrations and many networking opportunities.

NEPHELE was introduced in "SESSION 9 – Digital Twin: The Key to Digital Transformation" that took place on 6th July 2023. Our technical manager Anastasios Zafeiropoulos from the National Technical University of Athens presented "Development of a Virtual Object (VO) and an Associated Lightweight SoftwareStack (VOStack) for IoT Interoperability within the Computing Continuum" at 9:15 CEST

CITS 2023

10-12 July 2023, Genoa, Italy

Our colleague Panagiotis Papadimitriou from University of Macedonia was invited to give the Keynote Talk Towards the Convergence of IoT and Edge Computing: Opportunities and Challenges at the 2023 International Conference on Computer, Information, and Telecommunication Systems, (CITS 2023). This conference is an international forum for scientists, engineers, and practitioners to present their latest research and development results. The conference featured tutorials, technical paper presentations, and keynote talks.

Upcoming Events

87th Thessaloniki International Fair

9-17 September 2023, Thessaloniki, Greece

Our colleague Panagiotis Papadimitriou from University of Macedonia is planning a presentation of NEPHELE project at the prestigious Thessaloniki International Fair (TIF) next September. During a 9-day celebration, TIF is the annual meeting point of Greece's given political leadership with its citizens, aiming to inform them about its political and economic agenda for the upcoming year. TIF will present new market proposals in matters of technology, innovation, environmental protection, energy, education, start-up businesses, and e-governance, reflecting thus the modern socio-economic reality of the country.

CEICO 2023

4 December 2023, Taormina, Italy

The International Workshop on the Cloud-Edge-IoT Continuum for Hyper-Distributed Applications and Services (CEICO 2023) will be held on 4th December 2023 in conjunction with IEEE/ACM UCC 2023, in Taormina, Italy. This workshop is a collaborative effort between National Technical University of Athens and ZHAW Zurich University of Applied Sciences within the NEPHELE project.

MEET OUR PARTNERS

THIS SECTION WILL BE PRESENTING THE PARTNERS OF THE CONSORTIUM, THEIR PROFILE, MAIN EXPERTISE AND CONTRIBUTION TO THE PROJECT.

Inria

Inria (Institut National de Recherche en Informatique et Automatique) is the French National Institute for Computer Science and Applied Mathematics that promotes scientific excellence for technology transfer and society. Inria is a Public Scientific and Technical Research Establishment (EPST) under the double supervision of the French Ministry of National Education, Advanced Instruction and Research and the Ministry of Economy, Finance and Industry. Inria has 9 research centers distributed across France and one center abroad in Santiago de Chile.

As a technological institute, Inria supports the diversity of innovation pathways: from open source software publishing to the creation of technological startups. Inria transfers expertise and research results to companies (startups, SMEs and major groups) in fields as diverse as healthcare, transport, energy, communications, security and privacy protection, smart cities and the factory of the future.

More than 200 project teams work at Inria. The project team, an innovative model introduced by Inria at its creation, is the basic unit of the institution's research which bring together researchers with complementary skills to focus on specific scientific projects. Through this flexible model , Inria promotes the values of exchange, listening and collective intelligence, which are vital to the successful conduct of innovative research projects of excellence as from the start and guarantees close support to all its researchers.

The FUN team (Future Ubliquitous Networks) is the project team assigned to NEPHELE. This group focuses on self-organisation and services on wireless constrained devices, nodes and resources deployment, MAC and NET protocols, localization and security.

In NEPHELE, Inria is the leader of the requirements, reference architecture and Use Cases work package and the post-disaster scenario use case task, but also takes a very active part in other work packages and tasks.

- Inria website
- Inria FUN team
- Video: 139 seconds to discover Inria


Nathalie Mitton


Adriana Arteaga Arce


Hazem Chaabi

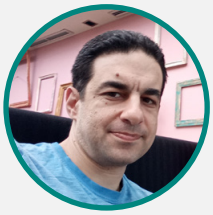
University of Macedonia

HELLENIC REPUBLIC
UNIVERSITY OF MACEDONIA

The University of Macedonia (UoM) is a public research university in Thessaloniki, Macedonia, Greece. Founded as School of Higher Industrial Studies of Thessaloniki in 1948, started its first operation during the academic year 1957–1958, and it is now the second largest university in the city. Today, the University has four Schools which consist of a total of eight Departments based in Thessaloniki (School of Economic and Regional Studies, School of Business Administration, School of Information Sciences and School of Social Sciences, Humanities and Arts).

Makis Fotoglou

Kostas Papadopoulos



Pantelis Rodis

The University gives particular emphasis on research which it is enhanced and promoted through all the University's available means. Close cooperation has been established with the industry and businesses of the private and public sector. For this reason, courses are often designed as part of either undergraduate or postgraduate study programs, with a view to meeting their specific needs, incorporating the latest developments in Greece and internationally, while members of the Research and Teaching Staff of the University's Departments implement educational and research programs in collaboration with large businesses and organisations.

The language of instruction is Greek, although there are programs in foreign languages, as well as courses for international and local students, carried out in English, French, German, Italian, Turkish, Russian, Serbian, Bulgarian and Arabic. The UoM has participated in more than 20 EU funded research projects.

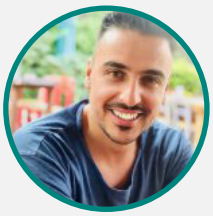
The NetCloud Research Group is in charge of the University of Macedonia participation in NEPHELE. The research topics of this group are AI assisted service and resource orchestration, network slicing, programmable dataplanes (P4), in-band network telemetry (INT) and Time-Sensitive Networking (TSN).

In NEPHELE, the UoM is leading the dissemination and communications activities work package and the task related to autonomic functionalities and ad-hoc clouds. UoM will also actively participate in many other tasks like use cases and architecture specification, IoT device supportive functions, compute resource, network management and synergetic orchestration, NEPHELE Platform and Dashboard, AI-assisted logistics operations use case and support programme.

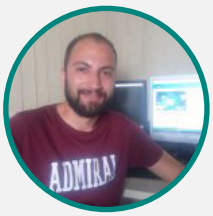
- University of Macedonia website
- UoM NetCloud group

Panagiotis Papadimitriou

Lefteris Mamatas



George Papathanail



Angelos Pentelas

FundingBox

FundingBox is Europe's Largest Deep Tech Funding Ecosystems.

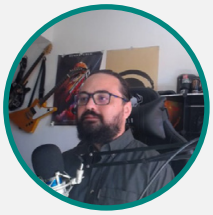
They help innovative startups, scale-ups and entrepreneurs ignite their growth and rewrite their future through easy-to-apply funding opportunities, exclusive partnerships with global brands and community knowledge. They join around 150 Tech Communities with more than 46 000 innovators and 1000 innovation partners registered.

Their areas of expertise are open calls management and financial support to third parties (FSTP) management in European Commission funded projects, communication & dissemination strategy, community building activities management, and EDIHs/ DIHs connection. Their experience includes managing of open calls & FSTP in 55 EU projects, with more than 150 Open Calls to be managed and 138 MEUR managed/distributed as FSTP.

In NEPHELE, the main activities of Funding Box are the Open Call and Support Programme management and the Community Building on Spaces.

Diana Järve

Weronika Gąsior



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