A lightweight software stack and synergetic meta-orchestration framework for the next generation compute continuum

Meta Operating Systems: Innovating the CEI landscape – Webinar
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Main Innovations in NEPHELE

• an **IoT and edge computing software stack** for leveraging virtualization of IoT devices at the edge part of the infrastructure and supporting openness and interoperability aspects in a device-independent way.

• a **synergetic meta-orchestration framework** for managing the coordination between cloud and edge computing orchestration platforms, through high-level scheduling supervision and definition, based on the adoption of a “system of systems” approach.
Open-source orchestration platforms

Eclipse Foundation, From DevOps to EdgeOps: A Vision for Edge Computing, White paper, 2021

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System of Systems Approach

What you can control

IoT to Edge to Cloud Continuum

Cloud Computing Infrastructure

what you are responsible for

Synergetic Meta-Orchestration

Edge Computing Infrastructure

IoT and Edge computing Software Stack

IoT Devices
VOs, Composite VOs and Application Graph
Virtual Object Stack - VOStack

Edge/Cloud Convergence Layer
- Data Exchange
- Semantic Interoperability
- Orchestration
- Multi-Tenancy

Backend Logic Layer
- Actions
- Alerts/Notifications
- Generic functions
- Data Management
- Event handlers
- IoT virtualized functions

Physical Convergence Layer
- Communication Protocols
- Security
- Networking Functionalities

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Stakeholders

Stakeholders include individual or groups within the system

- NEPHELE Operator
- Cloud-Edge Provider (CEP)
- IoT Provider
- Network Provider
- Application Service Provider (ASP)
- Service Consumer
Application Graph

Microservices
- Application Component
- Third party Service

Property: Secure Access
Requirement: Low Latency

Service Level Objective

Restriction: Deployment in the same location
Intent-based Orchestration

• What kind of actions can be performed and how the intent description should look like?
  • Compute resources management
  • Network resources management (SLAs/QoS assurance)
  • Security mechanisms?
  • Time sensitive networking functionalities?
• Can we come up with a formal intent description?
• What kind of technologies can be used for hierarchical decision making? How a system of systems approach can be materialized?
  • Autonomic control loops
• Consider orchestration in a multi-cluster environment
Intent-based Orchestration
Synergetic Orchestration Mechanisms

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RL-driven autoscaling of serverless functions in the computing continuum
Use case of Emergency/Disaster Recovery

Concept:
Establishment of a IoT–Edge–Cloud continuum for emergency initiatives, integration of sensor-carrying robots and smart devices in the continuum, deployment of edge computing for low-reception scenarios. Deploying an autonomous exploration and monitoring solution based on multiple robots that allows autonomous and adaptive exploration of an unknown area.

Benefits:
- Provide risk assessment tools to enhance situational awareness of the first responders
- Increased victim-locating capabilities through the processing of data from the sensors in the continuum
- Optimisation of injury assessment and treatment through data gathered by the smart devices
- Predictive emergency operations through system-wide analytics.
Use case of Energy Management in Smart Buildings/Cities

Concept:
Development and evaluation of Nephele technologies (Virtual Object and Virtual Object Stack). The goal is to apply these technologies in **intelligent monitoring** and **remote energy management** within the spectrum of **smart buildings**. The key objectives include the development of applications that facilitate **energy-efficient control**, the provision of personalized services to end-users, and the establishment of an automation schema grounded in **real-time data**. The use case is also focus on video analysis for detecting individuals and objects.

Benefits:
Real-time monitoring and data processing using **AI models** and **CEP rules** for decision making and control automation thanks to the aggregation of data from different sources. The use of Virtual Objects allows adding to constrained IoT devices **advanced computing capabilities** that allow **complex cryptography**, **advanced security systems**, **device intelligence**, **better management of device and network resources**, **improving performance and savings energy**, while offering broader and more intelligent control of the energy management systems.

- Secure communication in IoT device group
- Distributed complex decision making in buildings
- Distributed authorization scenarios
- True presence detection in building
- Communication radio offloading
- Customizable IoT devices to support energy-efficiency and well-being in buildings

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Use case of Smart Port

Concept:
By utilizing **Virtual Object** and **Virtual Object Stack** concept, data collected from multiple **sensors in the field** and **video cameras** are first (pre)processed in IoT gateway (far-edge), then combined with **business process related data** originating from Port Information system and processed in the edge, while certain specific tasks are delegated for the processing in the cloud, thus relying end-to-end onto the **IoT-Cloud-Edge Continuum** approach. **Optimizing process of routing containers** also include **machine-learning** algorithms for **problem-solving** and **risk avoidance** deployed at different components of IoT-Cloud-Edge Continuum.

Benefits:
Increase in **system flexibility, stability**, and **portability** will be achieved through IoT-Cloud-Edge Continuum harmonisation. Port stakeholders **resource optimisation** due to the containers routing process optimisation through decentralised predictive decision-making bringing also **increased coordination capabilities** with different external networks (road, railway), **reduced greenhouse gas emissions**, **security compliance** and **upgraded service level agreements**.

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Use case of Remote Healthcare

**Concept:**

The current ultrasound medical imaging processes are constrained by both the technical features of the local device and the knowledge of the local healthcare operator.

**Connect, decompose and virtualize ultrasound medical imaging systems** into the cloud-edge continuum to lose any barriers due to the hardware capabilities and localization of current physical systems.

**Benefits:**

Allow to **exchange data and resources** among the physical components involved in the use case.

Provide additional capabilities such as **distributed data management and analysis**.

Allow the orchestration of data and resources between the cloud and edge computing orchestration platforms.

**Virtualize ultrasound medical imaging systems** into the cloud-edge continuum

Ultrasound acquisition hardware and medical imaging viewers are required for this use case.
NEPHELE Open Calls

NEPHELE’s 1st Open Call

Extension of the Virtual Object Stack (VOSTack) and development of Virtual Objects (VOs), composite Virtual Objects (cVOs) and Digital Twins (DTs).

What do we offer?
Up to 8 Industrial SMEs/Mid-caps will receive up to 76,000 € funding per project.

Apply now

NEPHELE’s 2nd Open Call

Objective: validate the proposed architectural approach and synergetic meta-orchestration framework.

Onboarding of cloud-native hyper-distributed applications in the NEPHELE ecosystem (TRL 5).

Up to 8 Industrial SMEs/Mid-caps will receive up to 110,000 € funding per project.

Plan to be announced in Q3 of 2024.

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Thank you!

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