nephele

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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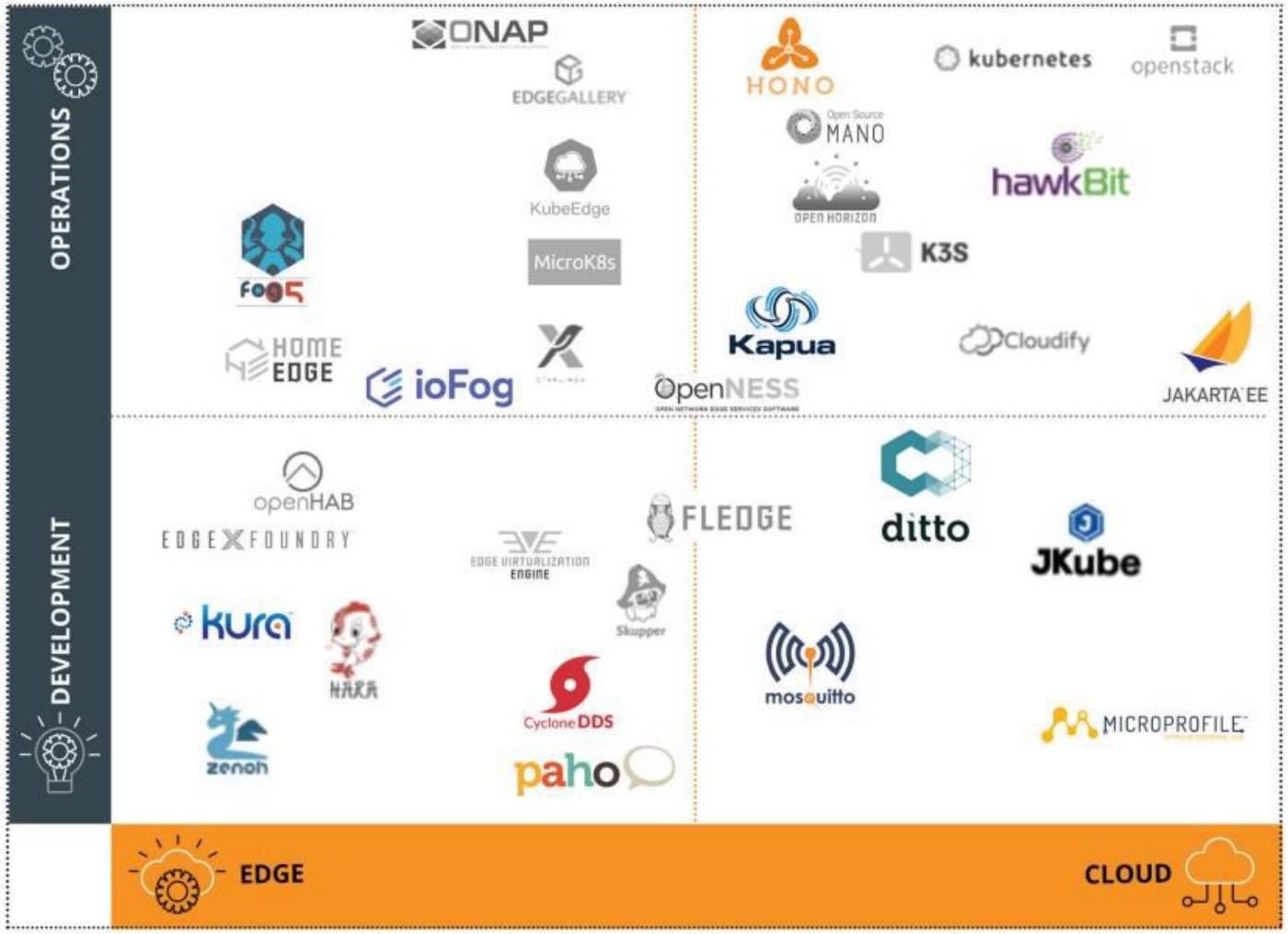
Main Innovations in NEPHELE

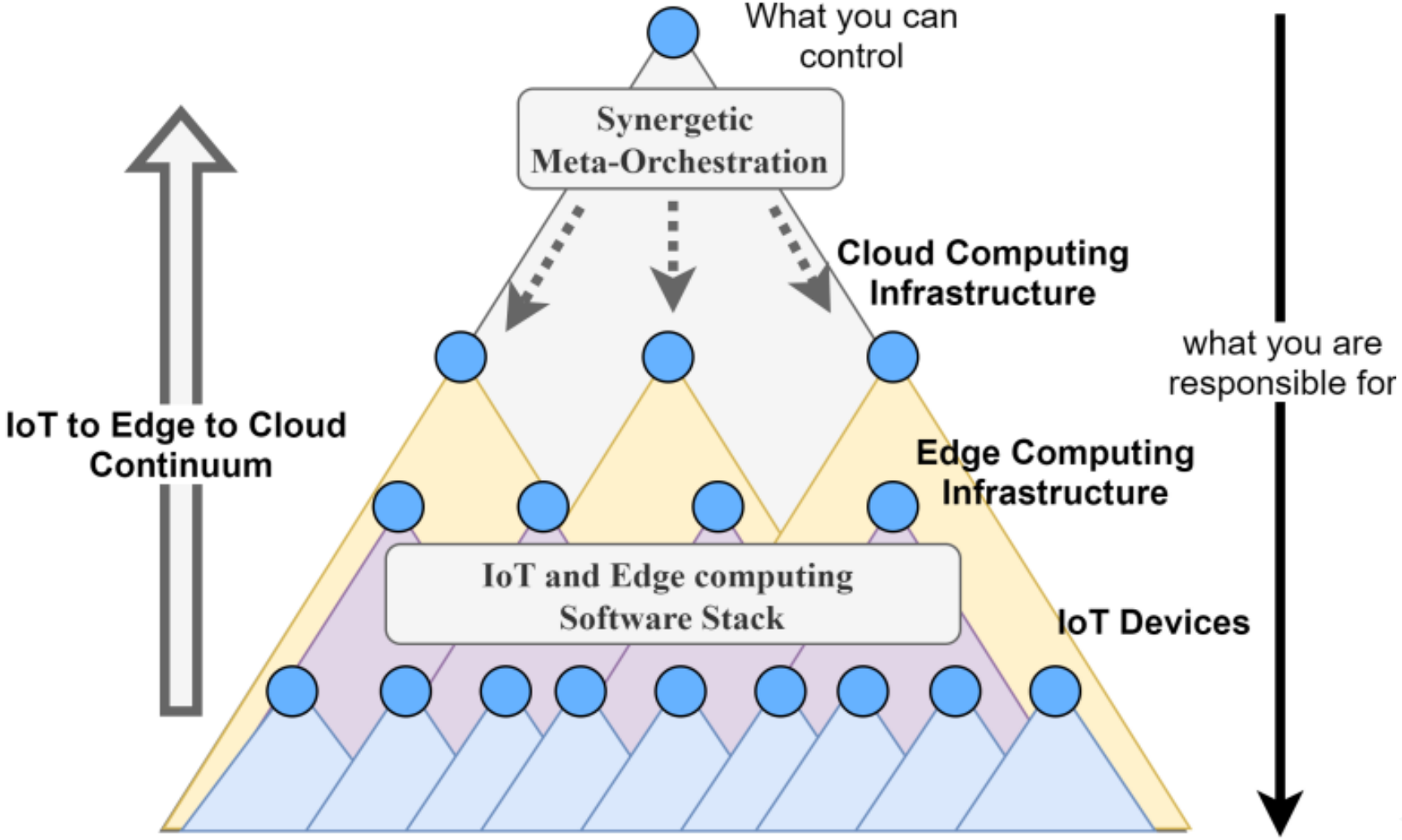
- an **IoT and edge computing software stack** for leveraging virtualization of IoT devices at the edge part of the infrastructure and supporting openness and interoperability aspects in a device-independent way.
- a **synergetic meta-orchestration framework** for managing the coordination between cloud 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

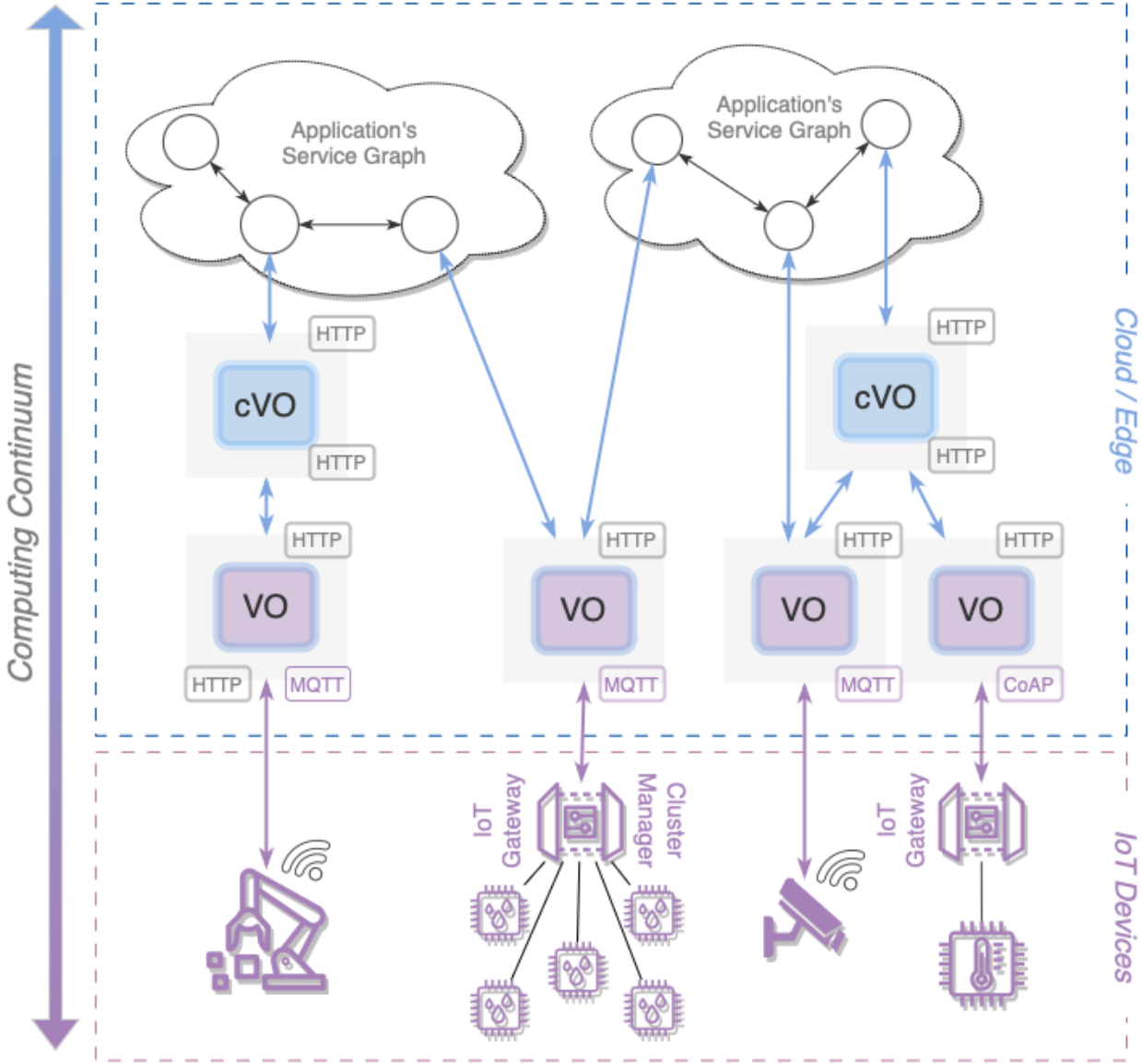


Eclipse Foundation, From DevOps to EdgeOps: A Vision for Edge Computing, White paper, 2021

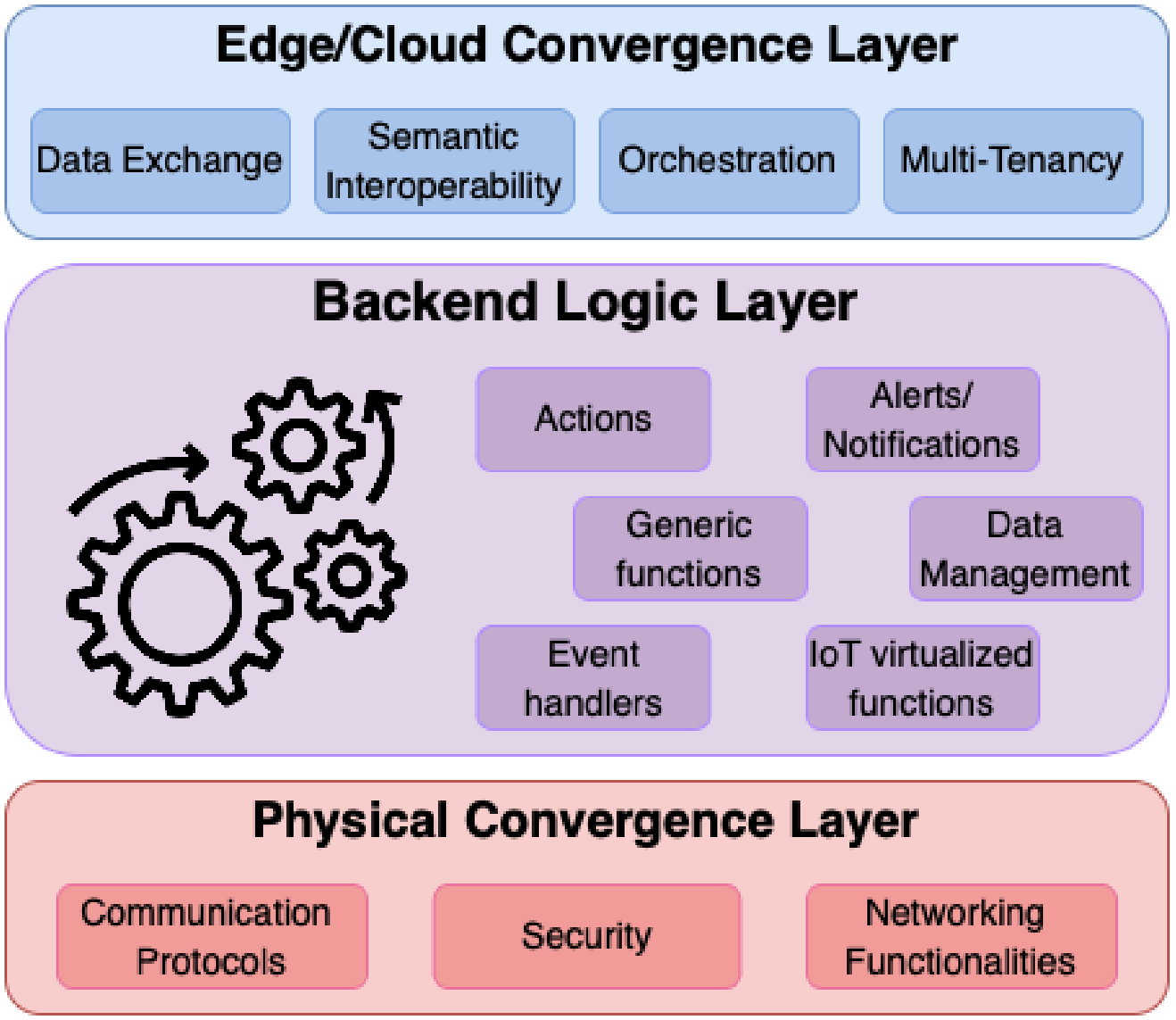
System of Systems Approach



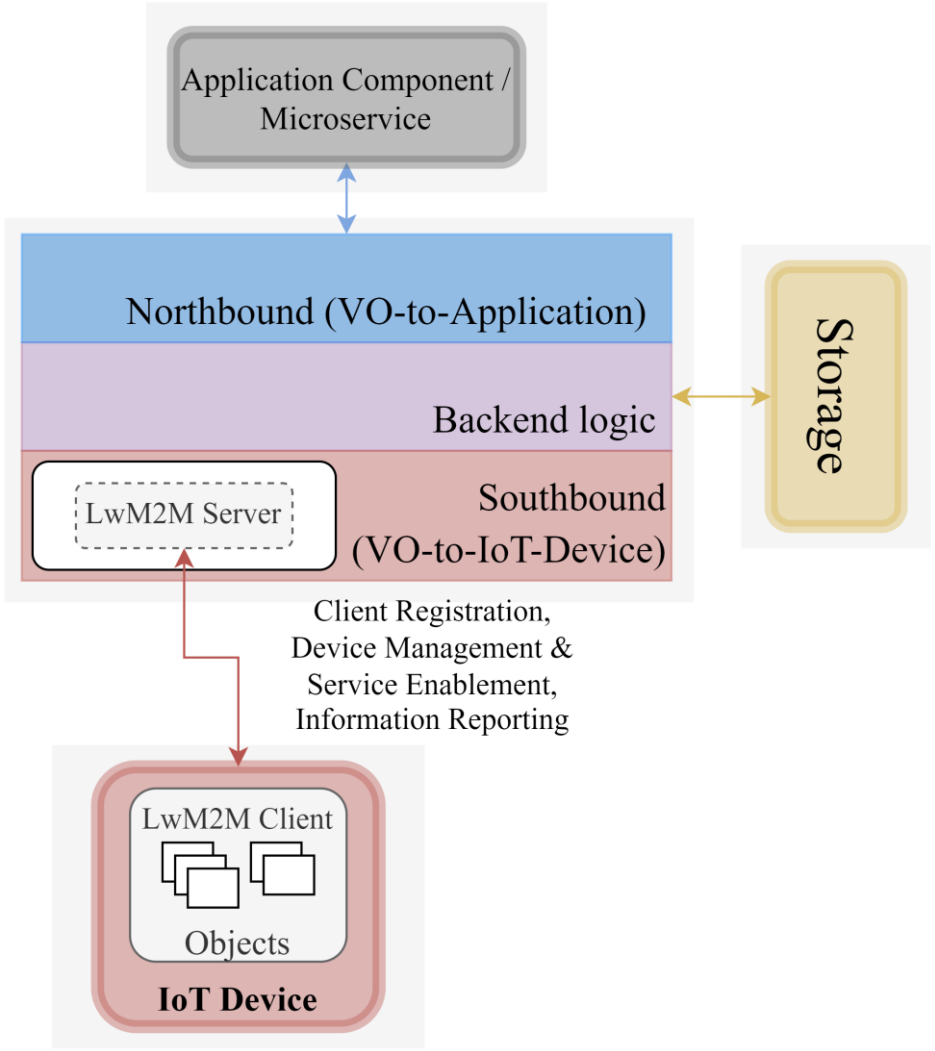
VOs, Composite VOs and Application Graph

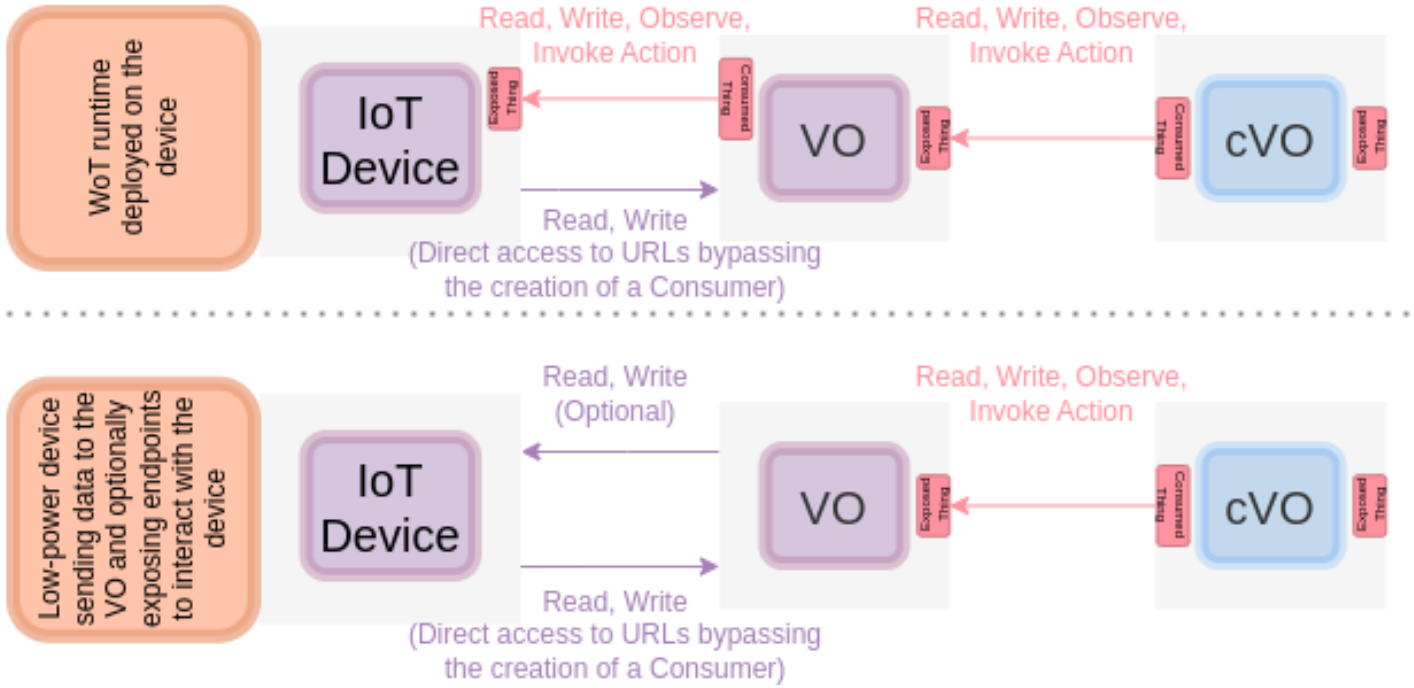


Virtual Object Stack - VOStack



VOs implementation

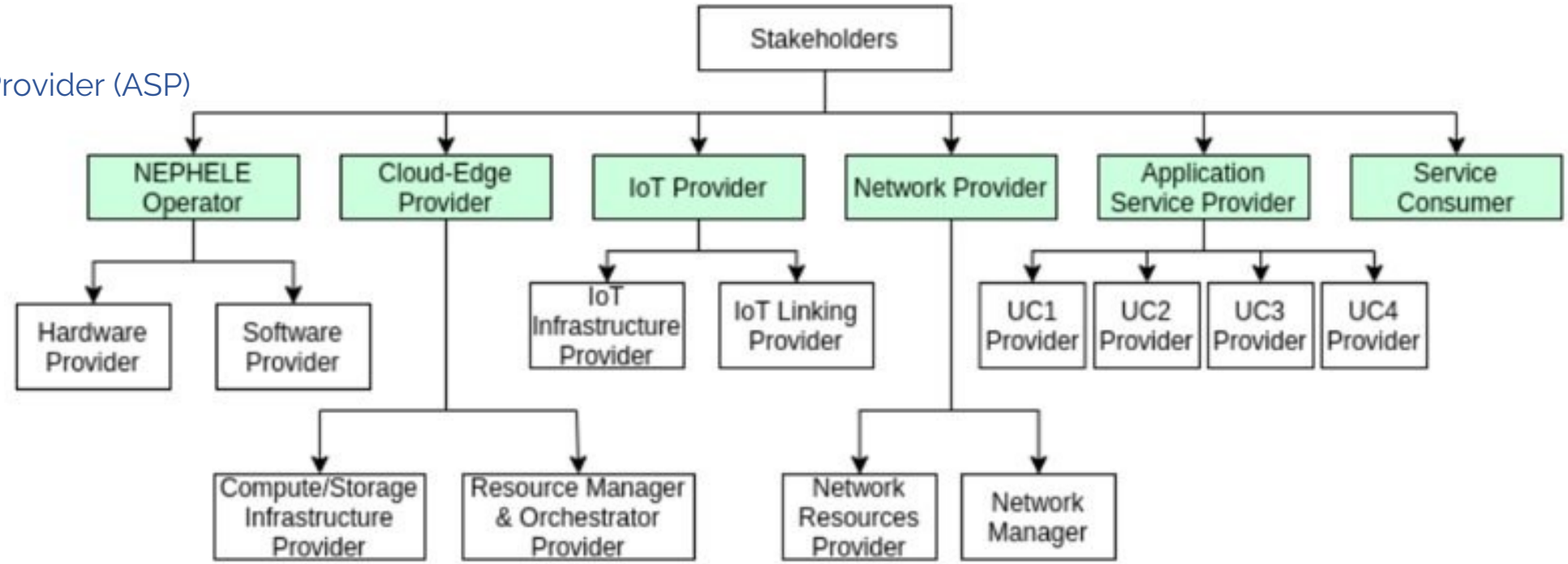




Stakeholders

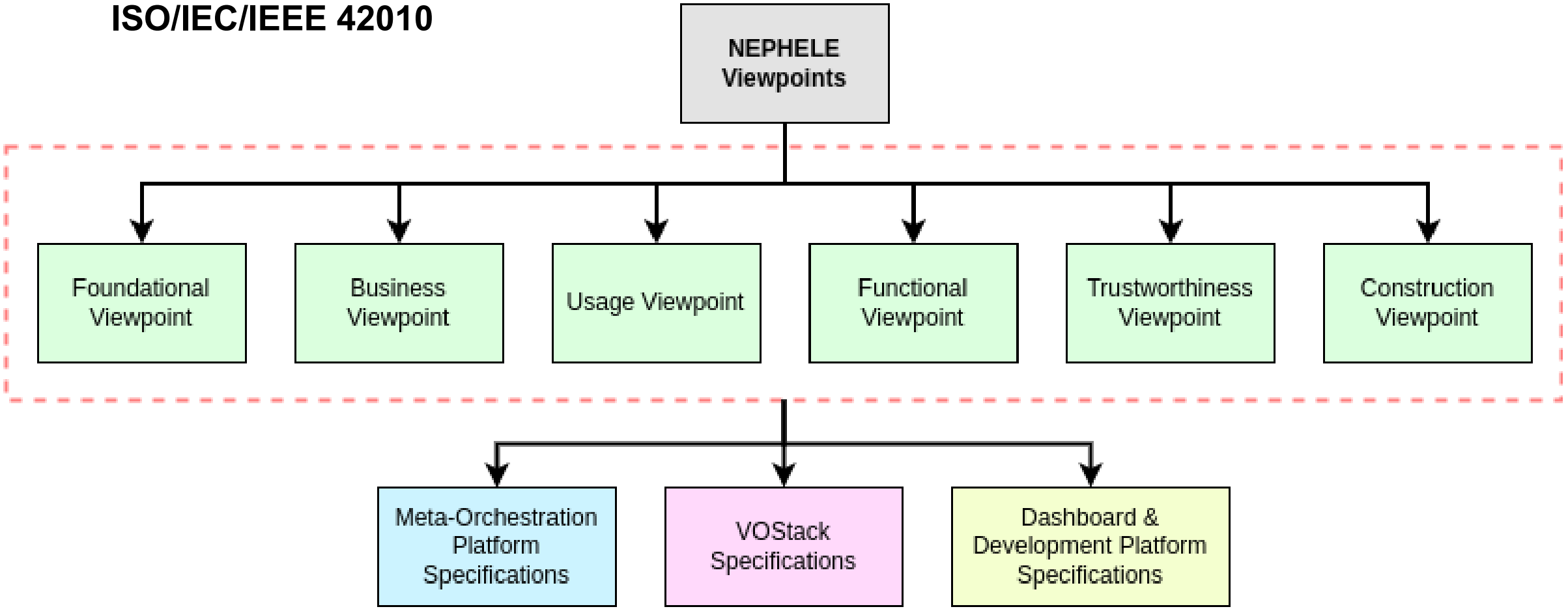
Stakeholders include individual or groups within the system

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

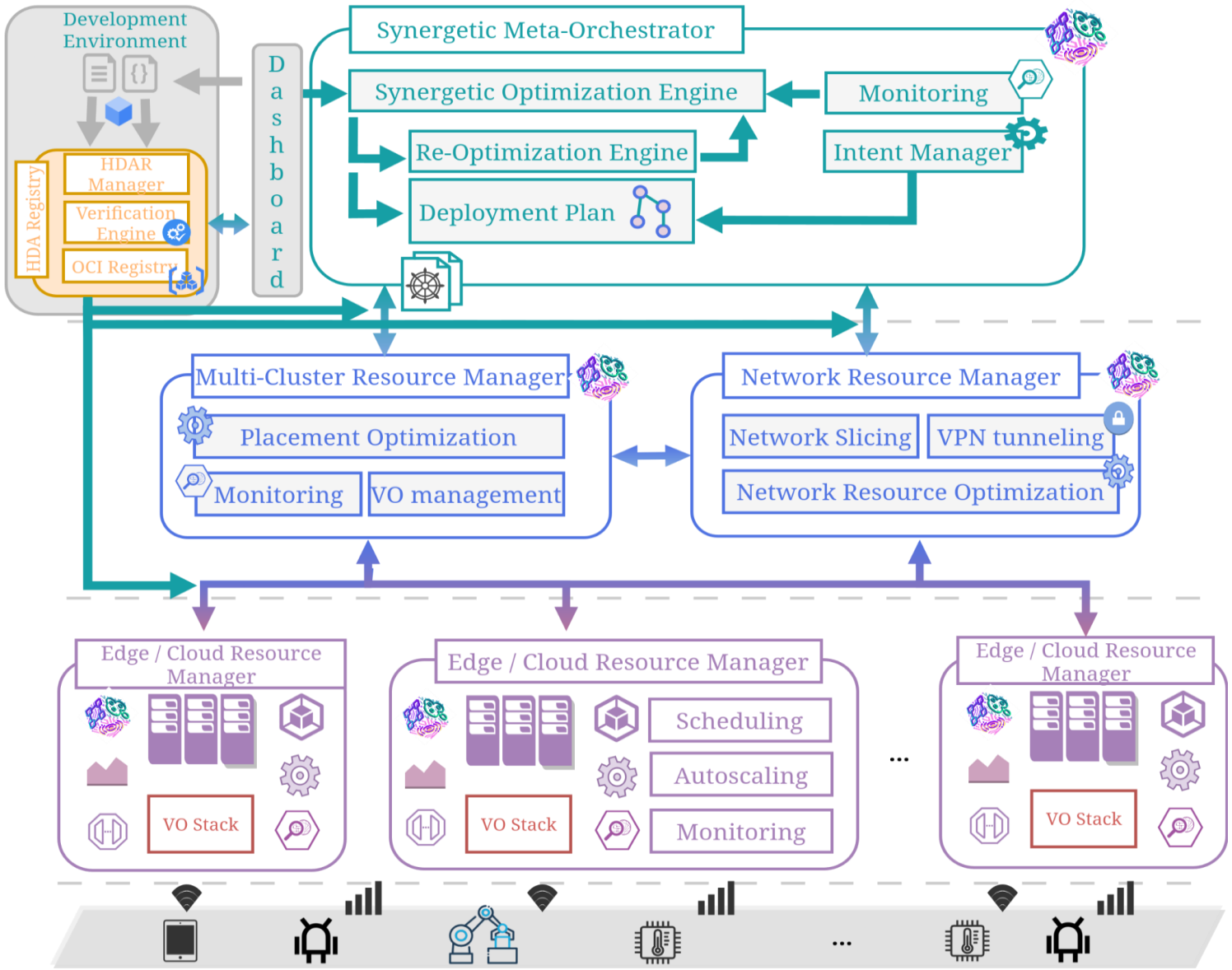


Viewpoints & Specifications

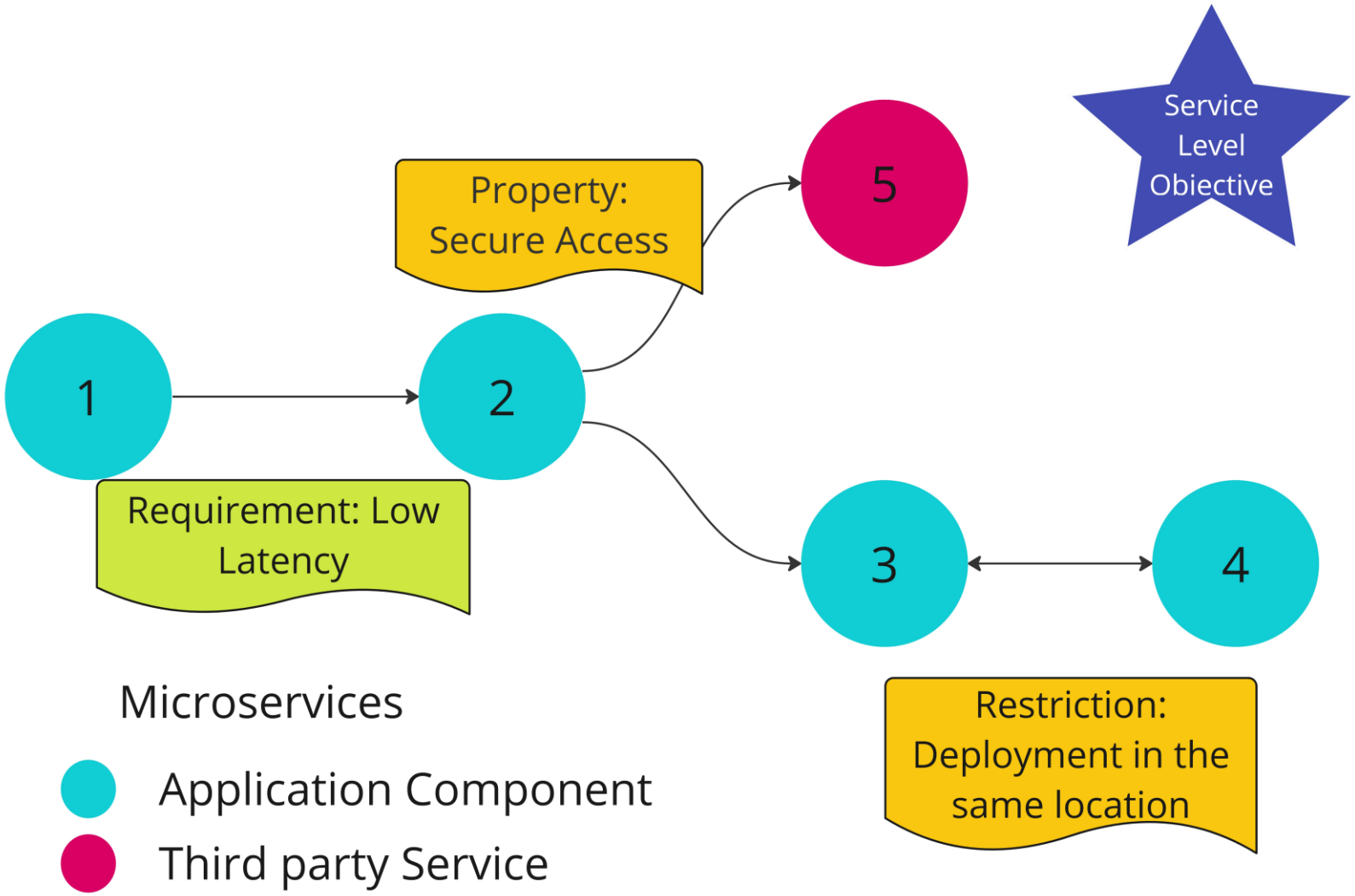
ISO/IEC/IEEE 42010



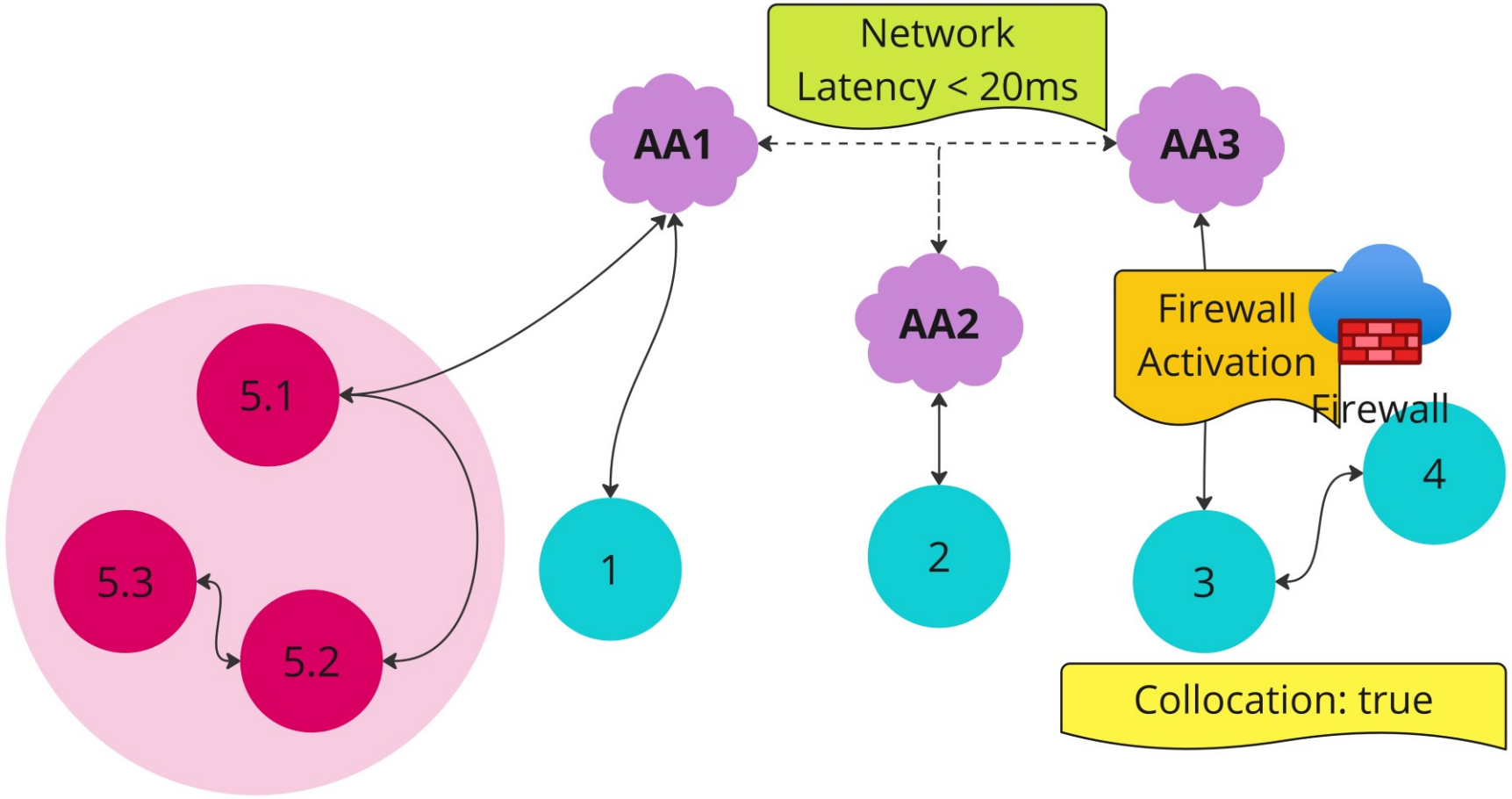
Reference Architecture



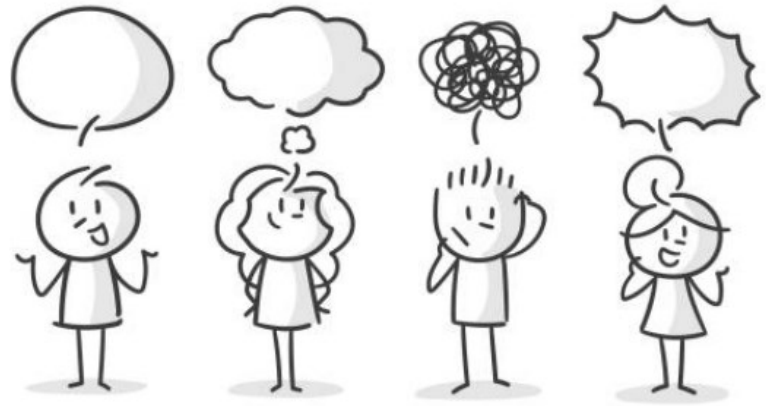
Application Graph



Application Graph

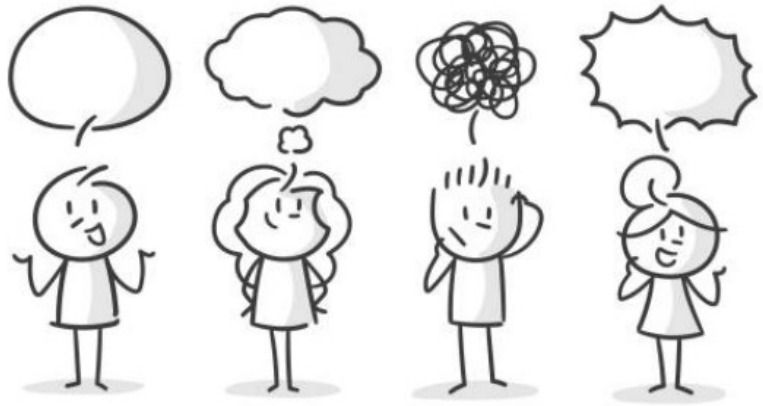


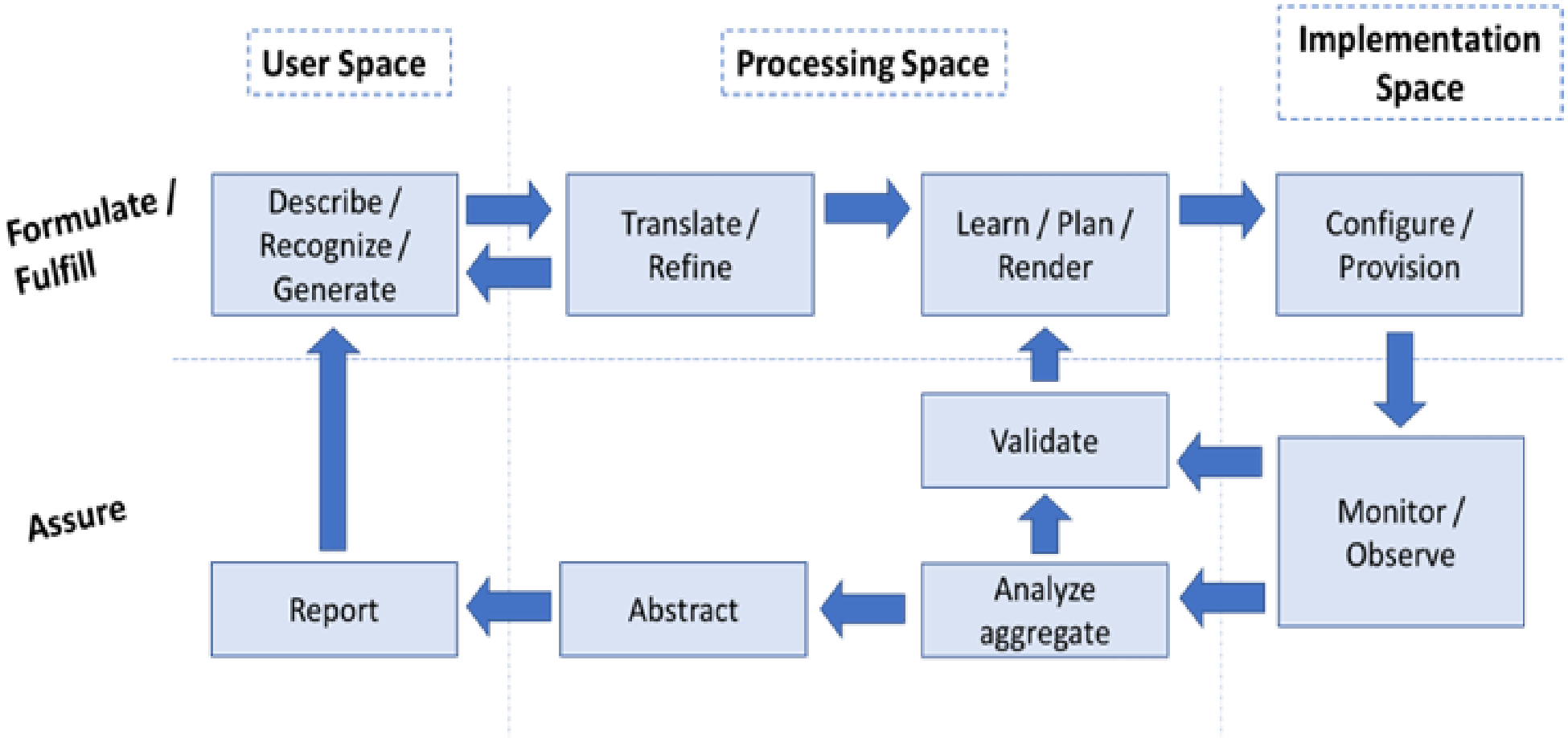
Intent-based Orchestration



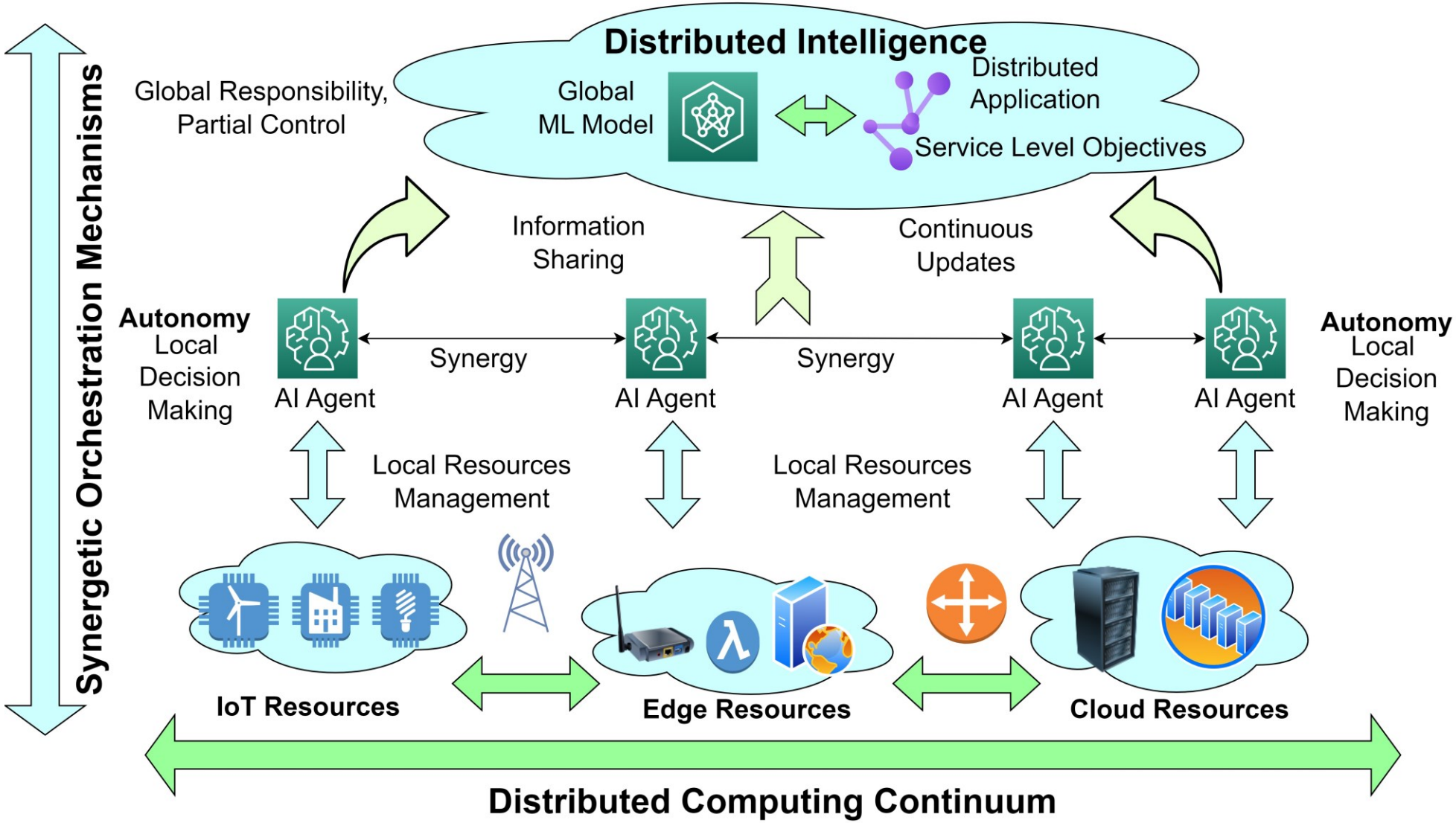
- What kind of actions can be performed and how the intent description should look like?
  - Compute resources management
  - Network resources management (SLAs/QoS assurance)
  - Security mechanisms?
  - Time sensitive networking functionalities?
- Can we come up with a formal intent description?
- 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

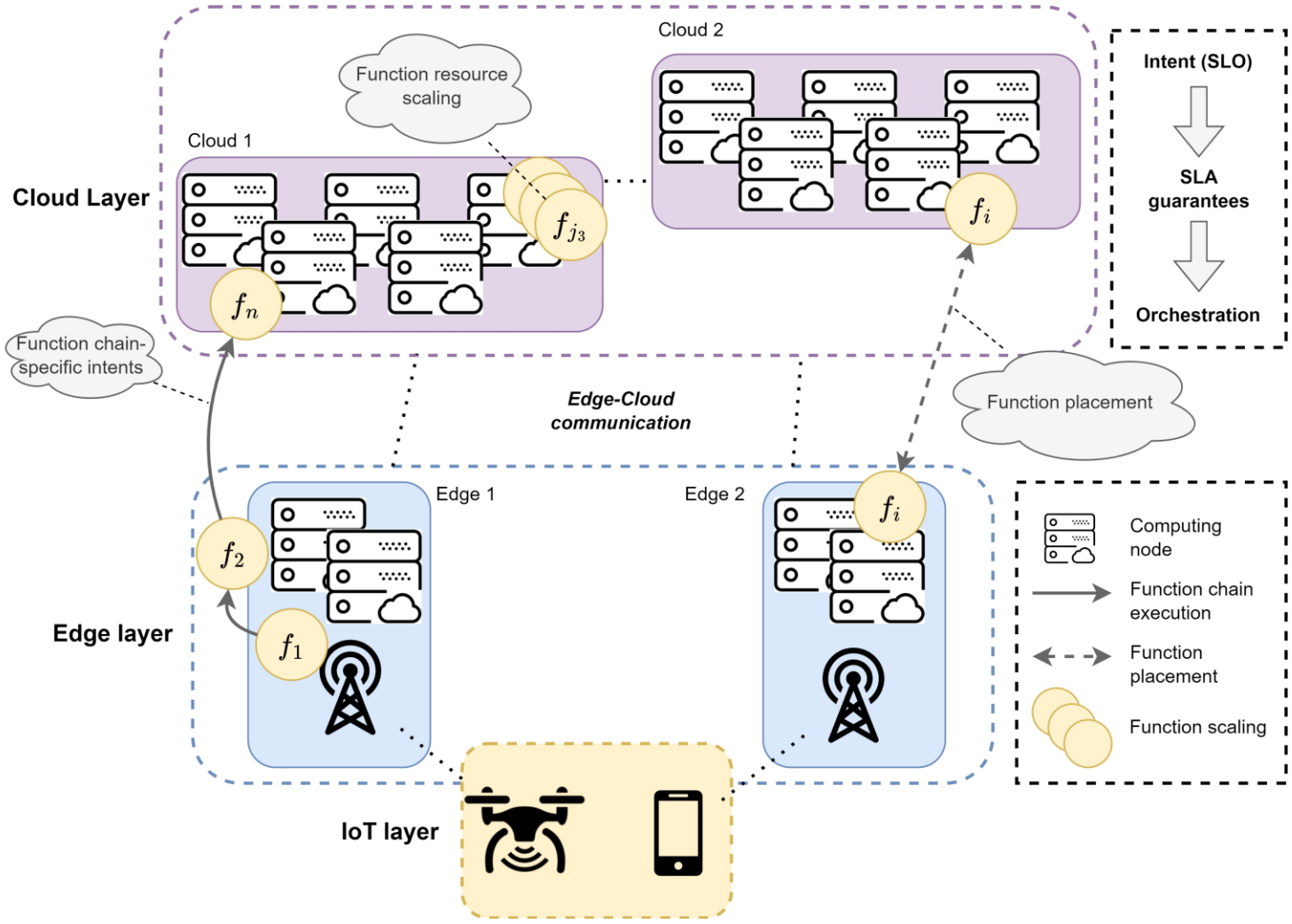


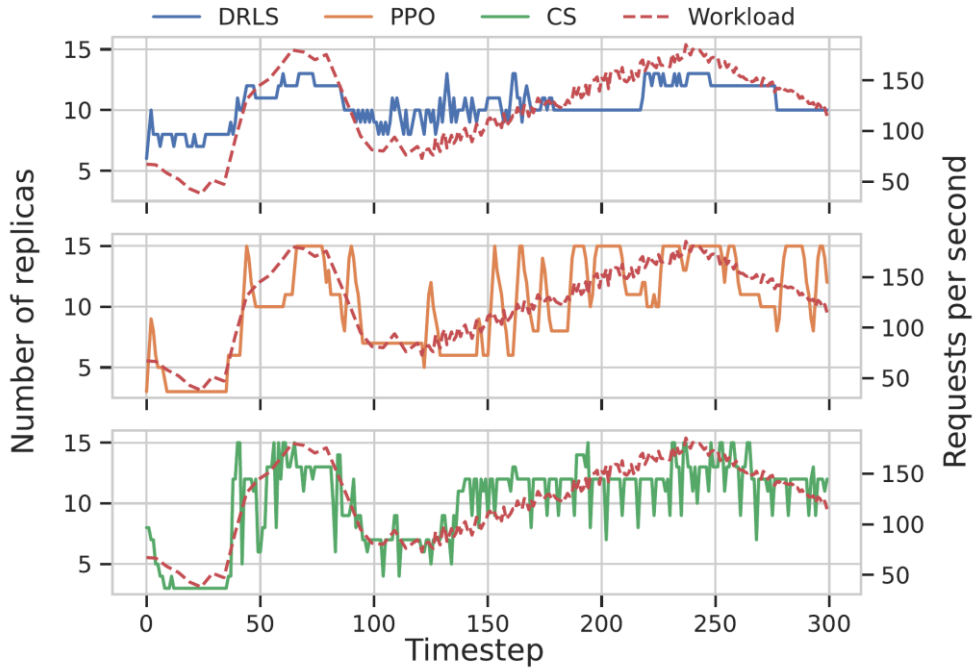


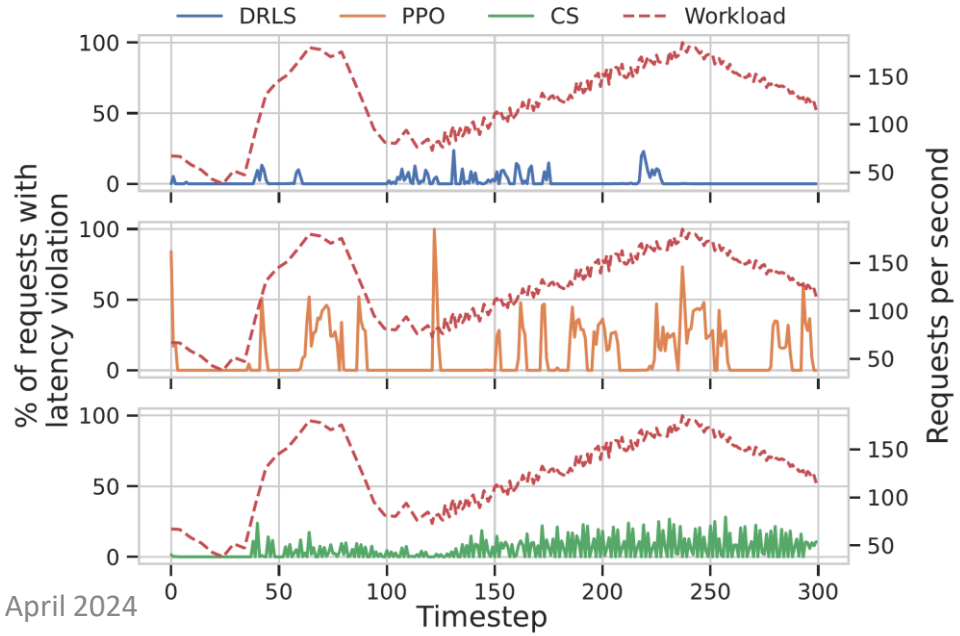
Synergetic Orchestration Mechanisms



RL-driven autoscaling of serverless functions in the computing continuum



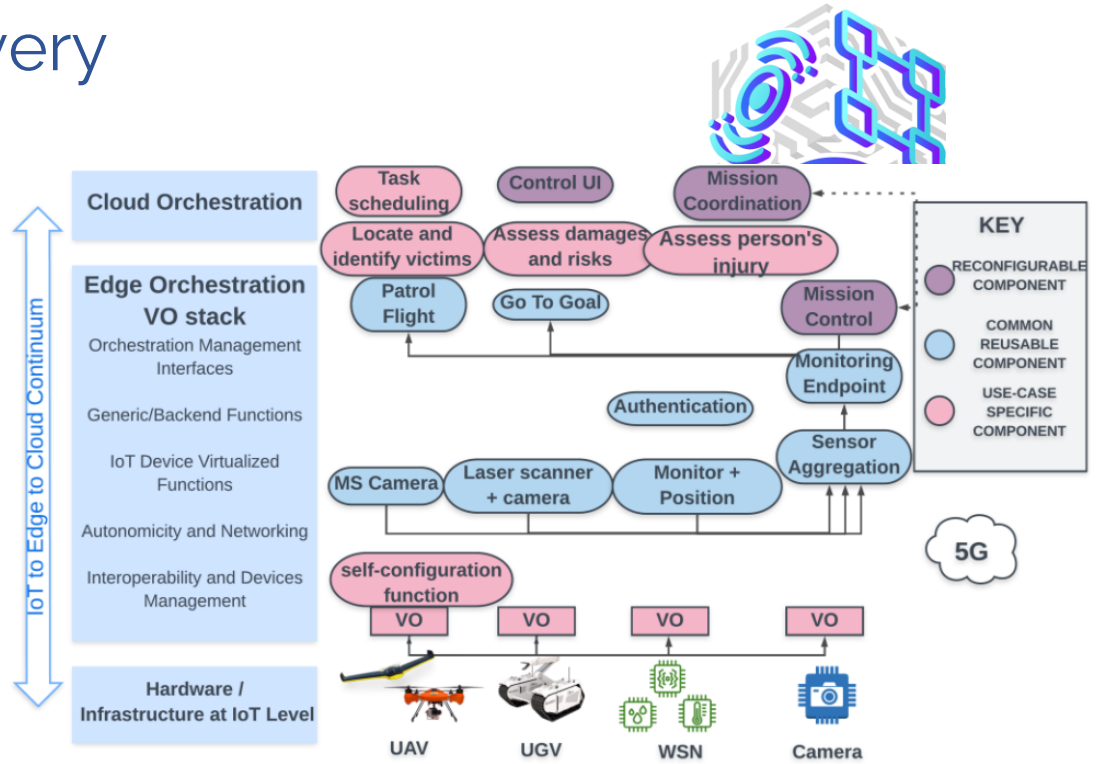




Use case of Emergency/Disaster Recovery

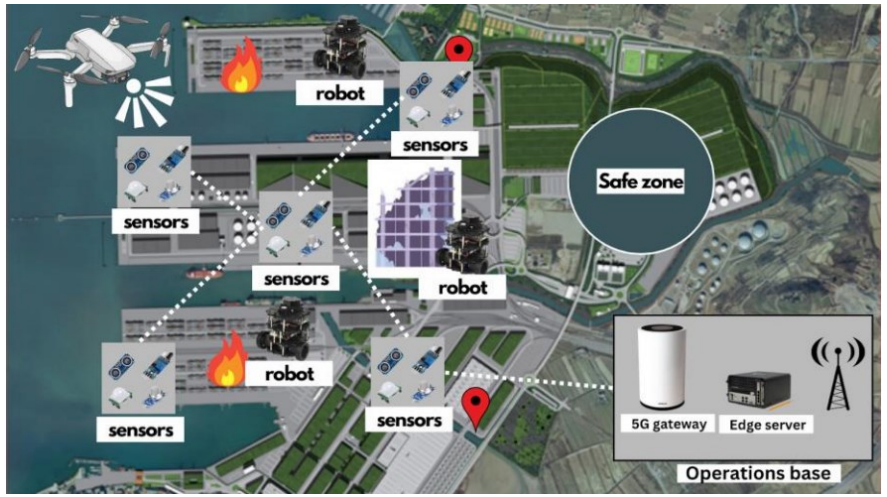
Concept:

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.



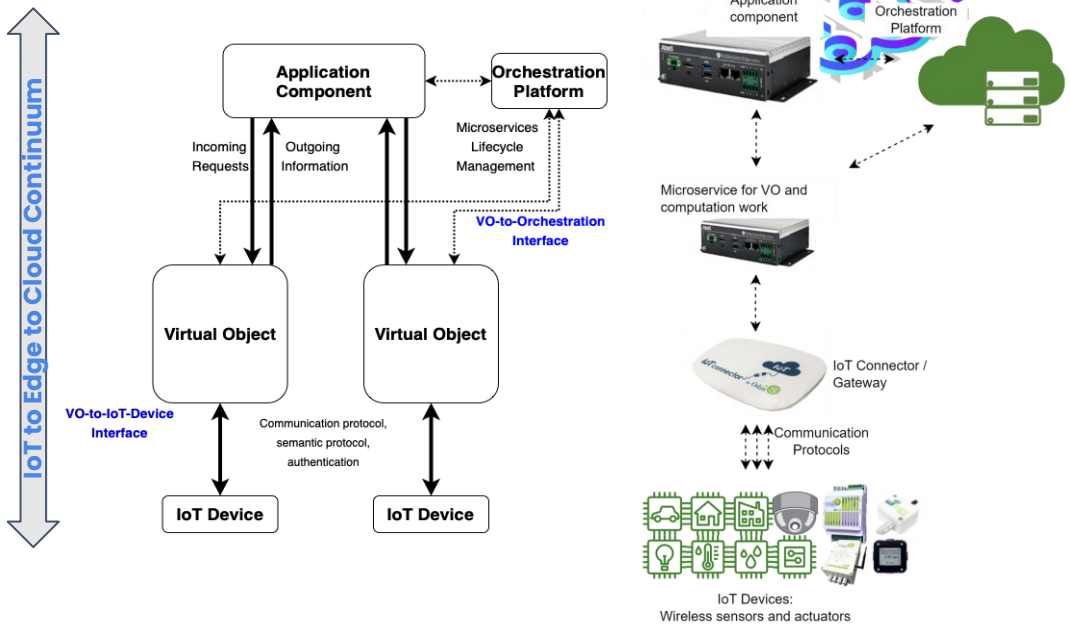
Use case of Energy Management in Smart Buildings/Cities

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

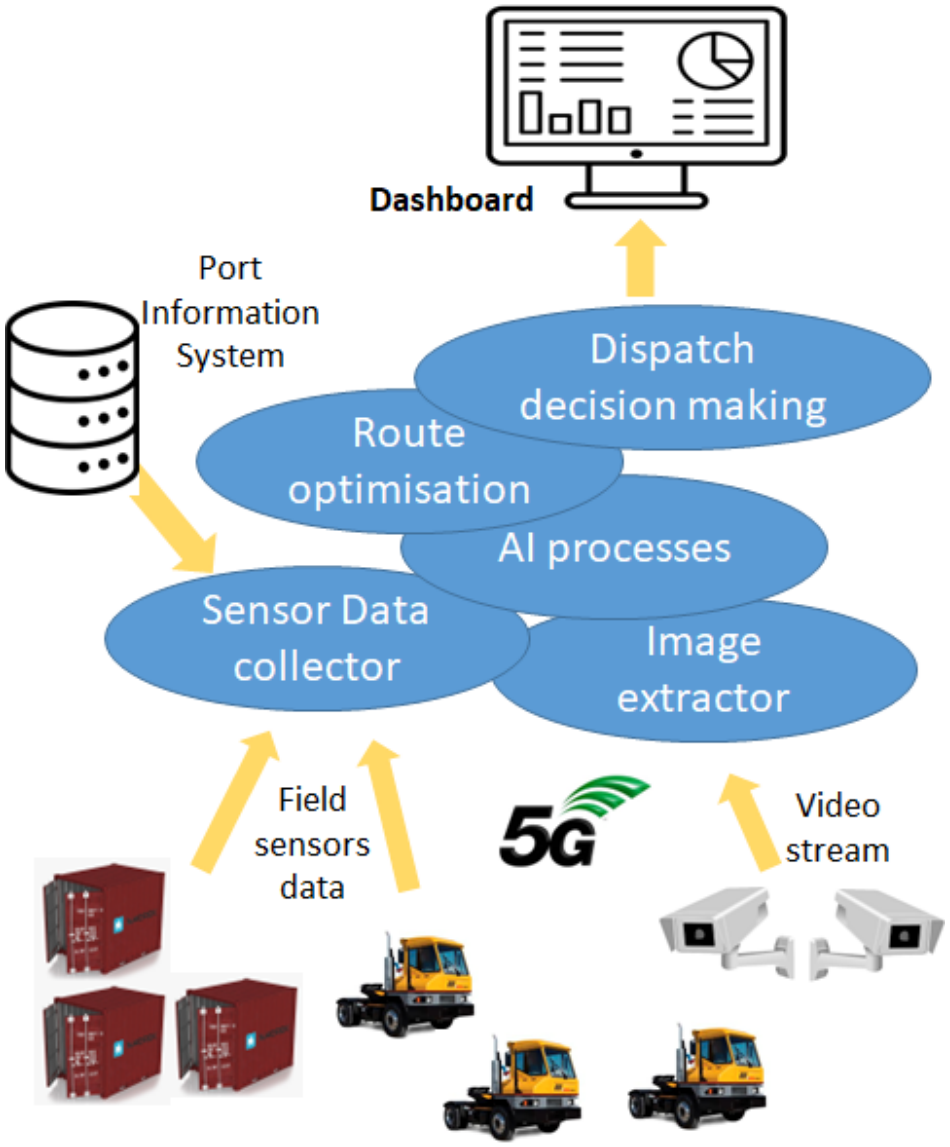
Use case of Smart Port

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**.



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.

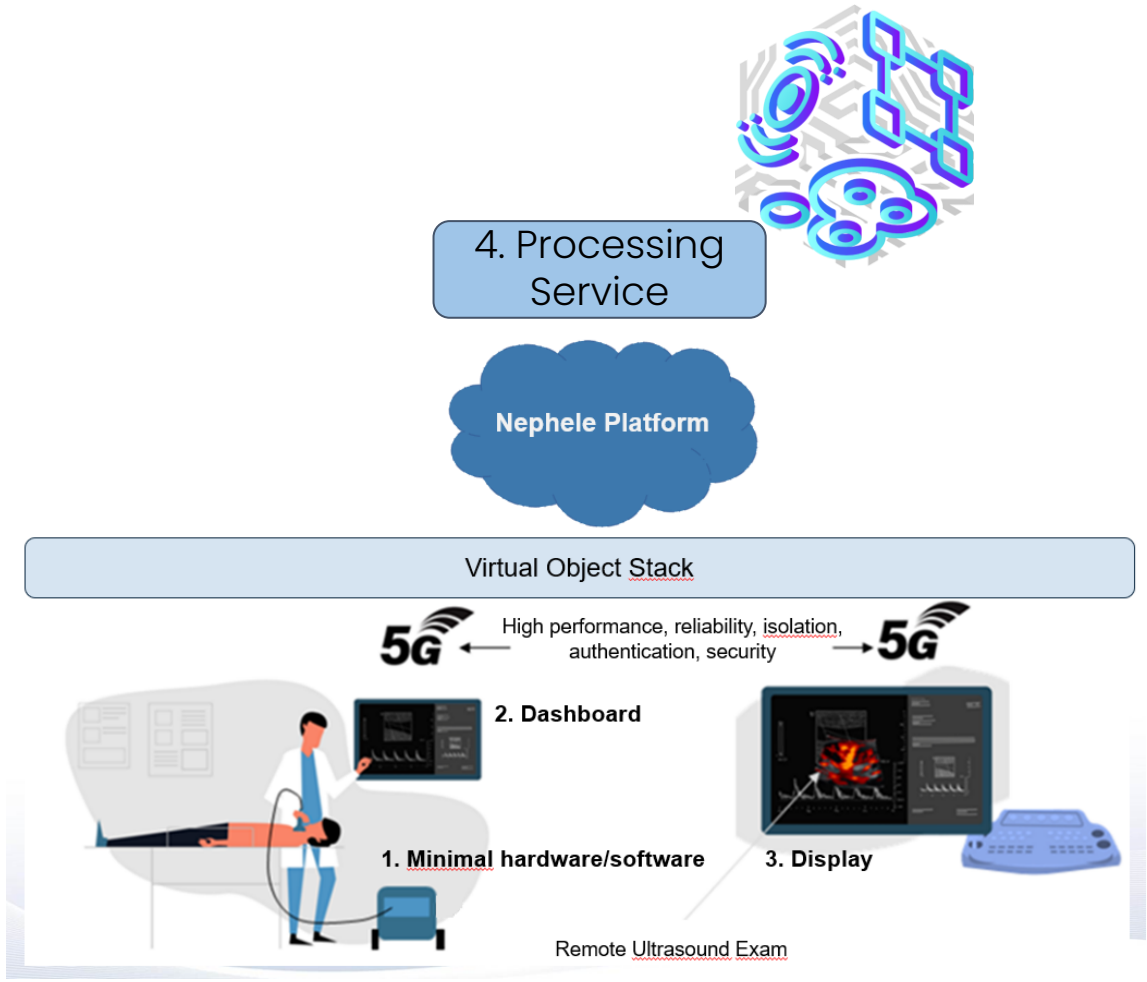
Benefits:

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**.

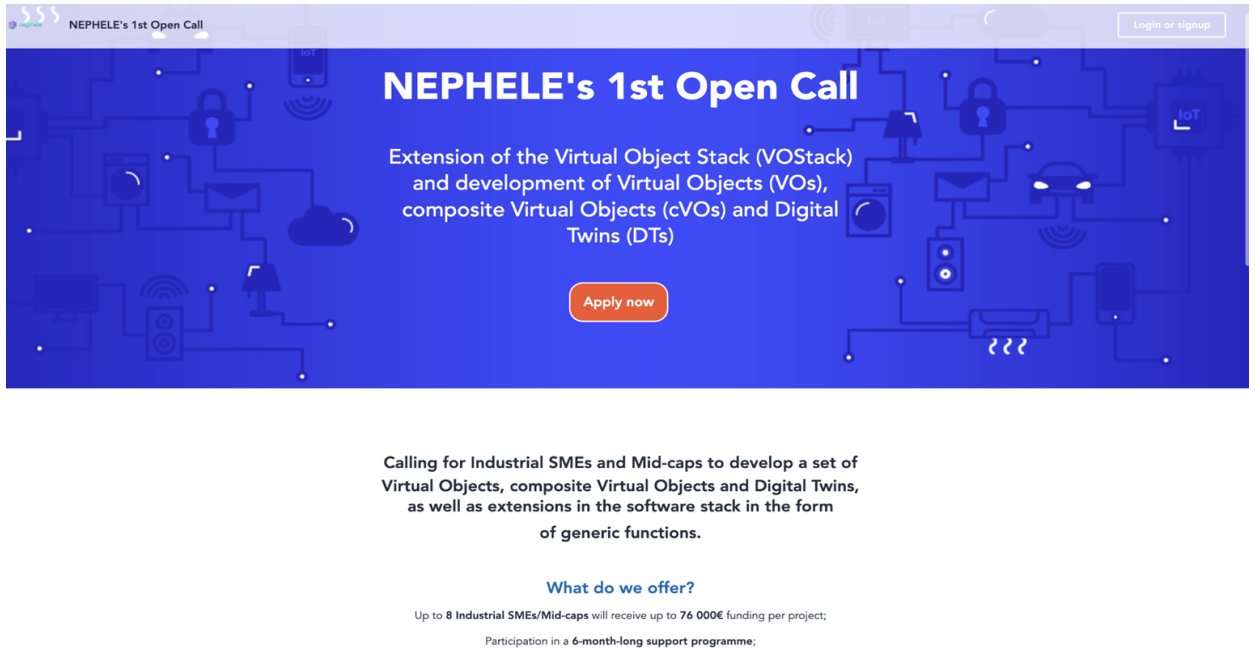
Allow the orchestration of data and resources between the cloud and edge computing orchestration platforms.

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 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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