nephele

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

Use Case #3: Energy management in smart buildings/cities

Rafael Marín – Odin Solutions S.L.
Alejandro Arias – Odin Solutions S.L.

Use Case #3: Energy management in smart buildings/cities

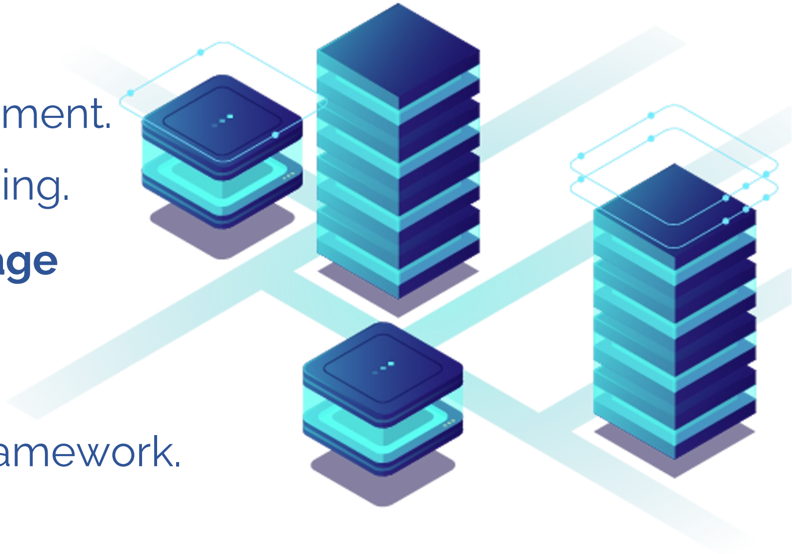
Partners: ODINS (support of SIEMENS and IBM)

Duration: M16 – M36 i.e. January 2024 – September 2025

Description: development & evaluation of NEPHELE technologies for **intelligent monitoring and remote energy management** in a testbed scenario of smart building provided by ODINS in Murcia,

Objectives:

- To develop applications to allow **energy efficient control** actions of building equipment.
- To offer customized services to end-users to improve energy-efficient and well-being.
- To provide an automation scheme based on **real-time information and video/image processing** from different IoT devices and Edge nodes.



Nephele integration: The smart energy services will be:

- Implemented with VOStack in Edge nodes by the integrated meta-orchestration framework.

Technical challenges:

- **Data security** is of paramount importance for smart building applications, especially when end users' data form part of the decision processes.
- **Real-time or almost real-time** execution of data analysis for complex event decisions.

NEPHELE Use Cases

Use case	Use Case #1	Use Case #2	Use Case #3	Use Case #4
Industrial Domain	Post-disaster Search and Rescue	AI-assisted Logistics Operations	Energy management	Remote healthcare services
Edge/Cloud Functions	Risk assessment, Victim/Object Detection, Mission Management, Mapping	Route optimisation, Traffic management, Forecasting	Decision making, Secure access, Radio offloading	Medical report, Diagnosis, Dashboard
Generic/Supportive Functions	Data Aggregation, Authentication, Telemetry	Load balancing, Live migration	Distributed AI, Authentication, Distributed Authorisation	Load balancing, Data management
Virtualized IoT Functions	Object detection, monitoring, Image processing	Video transcoding, Object detection	Image analysis, Video transcoding, consumption analysis	Image processing
IoT Management Functions	Bootstrapping, self-configuration, self-healing	Self-healing, ad-hoc networking	Blockchain, Encryption	Authentication, Network isolation
Intelligent IoT Devices	Ground Robots, Drones Cameras, Sensors	5G IoT gateway, Drones, UHD cameras	System-on-chip devices, cameras, power meters	Medical imaging, Ultrasound HW
Participant Testbed	INRIA, ZHAW	ININ, UOM	ODINS, SIEMENS, IBM	CNIT

Use Case #3: Energy management in smart buildings/cities

This use case will provide several **applications and services**:

I. **Distributed complex decision making**, where VOs Edge nodes will perform **intelligent energy saving actions** not only based on the sensor measures collected by the IoT devices managed, but also the information and data coming from other nodes. This will drive the efficient use of renewable energy sources and the reduction of peaks in the energy consumption.

II. **Distributed authorization scenarios** where an access request to a resource is not decided exclusively by a centralized cloud platform but made by a back-end service leveraging in a Distributed Ledger Technology (DLT), that stores distributed access control policies, (e.g., distributed-XACML), employed at the edge nodes closest to the target resource to enforce access.

III. **Object/Person detection through AI-assisted image processing** tasks running in distributed Edge nodes. This is achieved from the data collected by video cameras deployed in the scenario for finding dangerous or suspicious objects, and getting the location of vulnerable persons, such as missing children or lost elders.

Use Case #3: Energy management in smart buildings/cities

This use case will implement several applications:

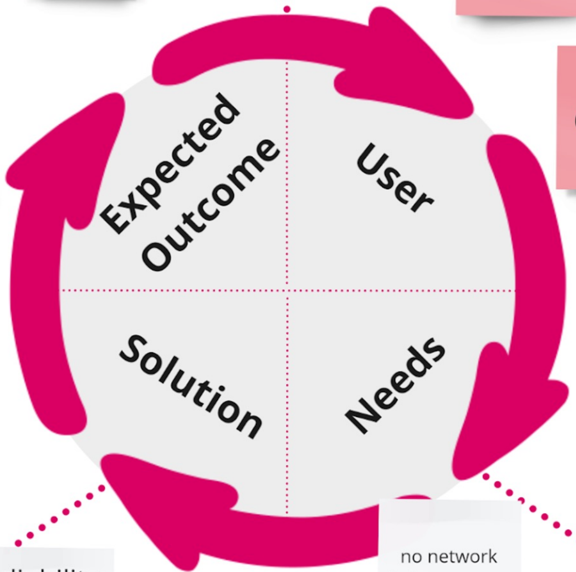
IV. **Communication radio offloading** for battery-powered devices or subscription base technologies. Decentralized AI-assisted orchestration of VOs may avoid certain radio channels to save either IoT device battery or subscriber data, by offloading the communication flows to auxiliary technologies (e.g., switching from NB-IoT to WiFi access point).

V. **Customization IoT devices to support energy-efficiency and well-being in buildings**. As extension of case II, this application will demonstrate how the true presence in rooms can be easily determined and how that information can be used to make a Building Automation Systems (BAS) more energy efficient.

Use Case #3: Stakeholders, locations and constrains

Stakeholders: all parties participating or affected by the use case

- energy providers
- energy communities
- architects & builders
- network operators
- HVAC manufacturers & installers
- IoT device manufactures
- appliance manufacturers
- businesses and companies
- ministry of economy, transport & industry
- citizens
- city government



Location of the use case, physical or virtual (as specific as possible)

- cloud
- buildings
- urban furniture
- edge
- appliances
- gateways
- Cameras
- network infrastructure
- sensors
- smartphones

Constrains, challenges & risks

- reliability of the network
- no network infrastructure
- trust
- user data security
- economic risks
- constrained IoT devices
- privacy risk
- heterogeneous devices
- regualtory limitations
- real-time execution

Use Case #3: Stakeholders, locations and constrains

Stakeholders

Citizens, Local government, Building managers and energy communities, and security services

Locations

Buildings, urban furniture, lighting systems, traffic lights, IoT devices, HVAC systems, …

Constrains

Advanced data analysis, privacy preserving of the dataset, regulatory limitations

Challenges

Real time data, security of communication, privacy, network connectivity, support heterogeneous devices, provide user-friendly interfaces to simplify the interaction with VOs and applications

Risks

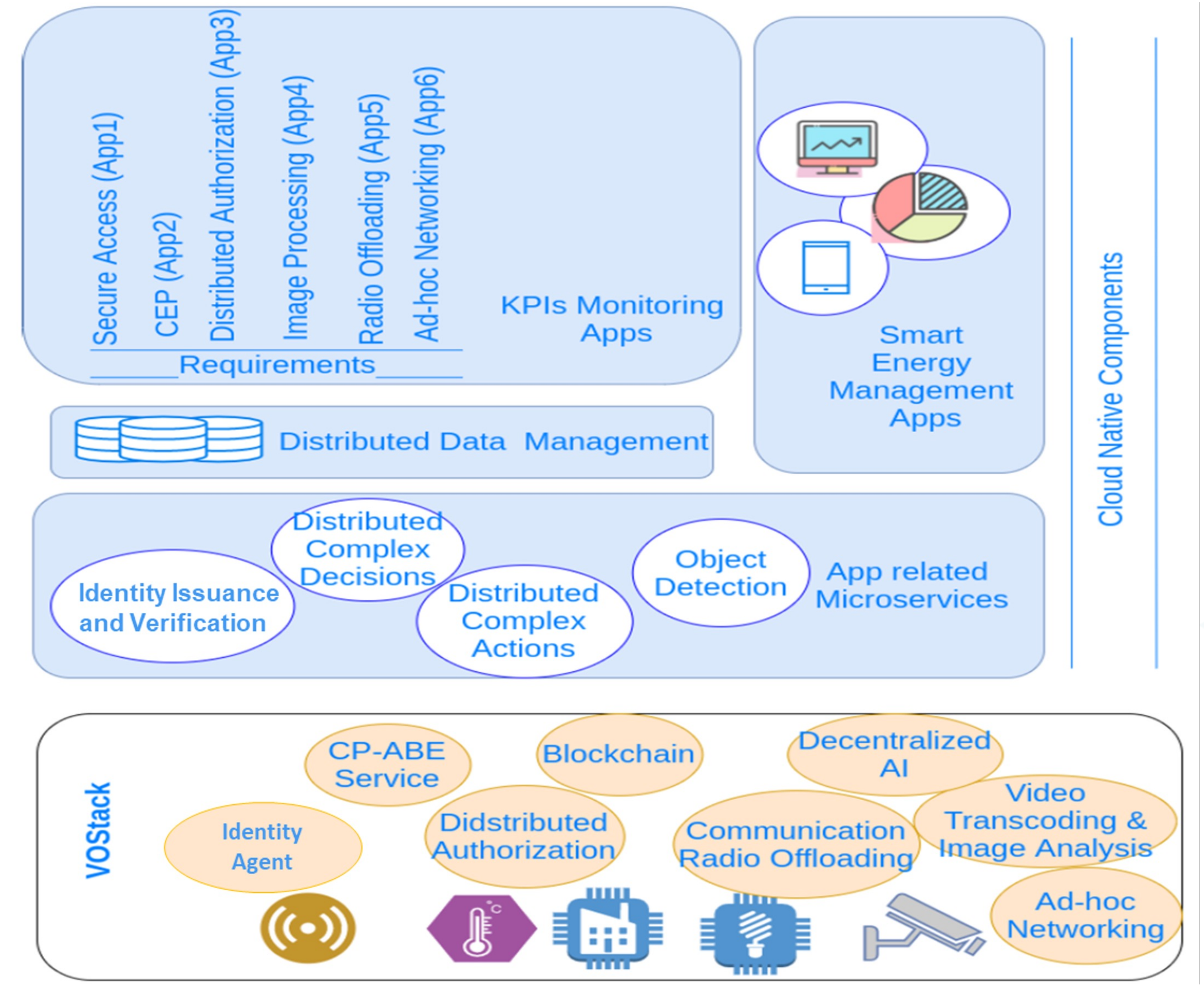
Privacy and economic risks

Use Case #3: Energy management in smart buildings/cities

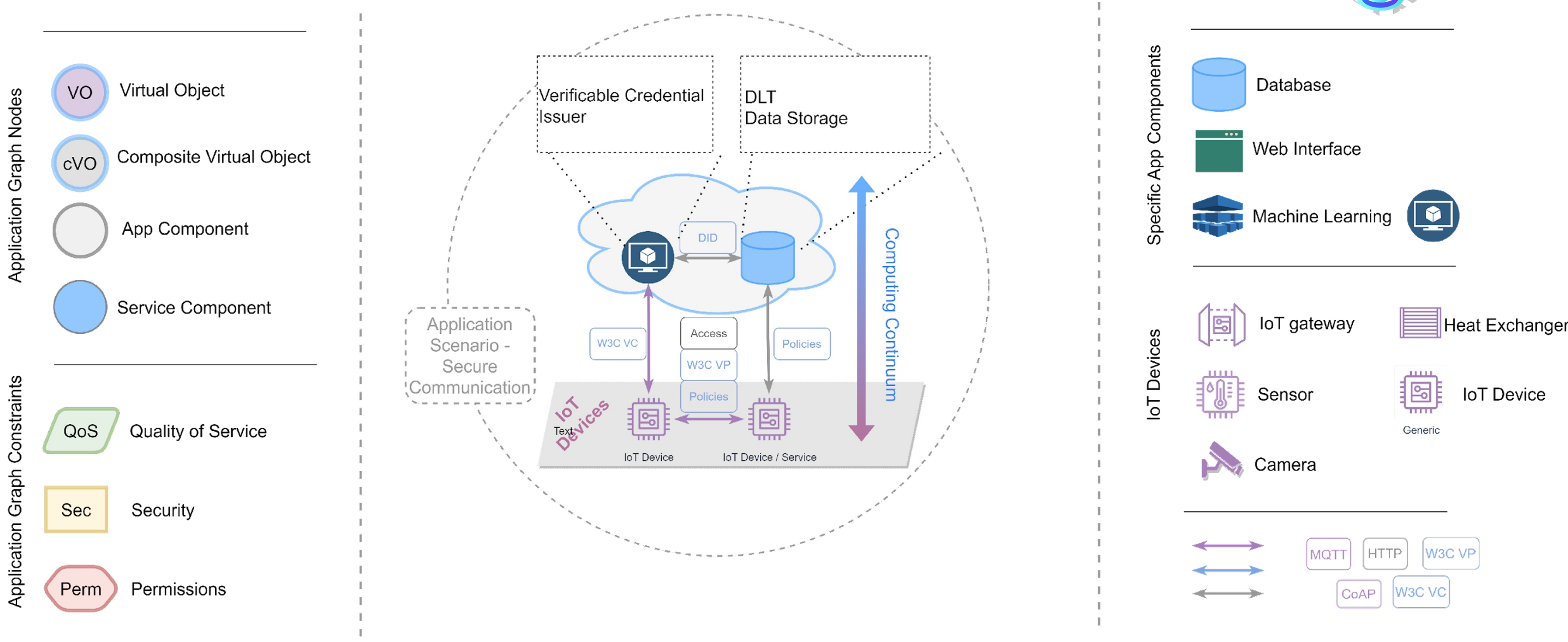
This use case will collect the following **functionalities**:

- Software component orchestration
- Device customization and management
- Device interoperability standardized interfaces
- Access control management
- Identity management (issuers and verifiers)
- Data storage service
    - Secure
    - Decentralized
- Low latency communication
- Computer vision for information extraction
- Intelligent data filtering/aggregation/compression

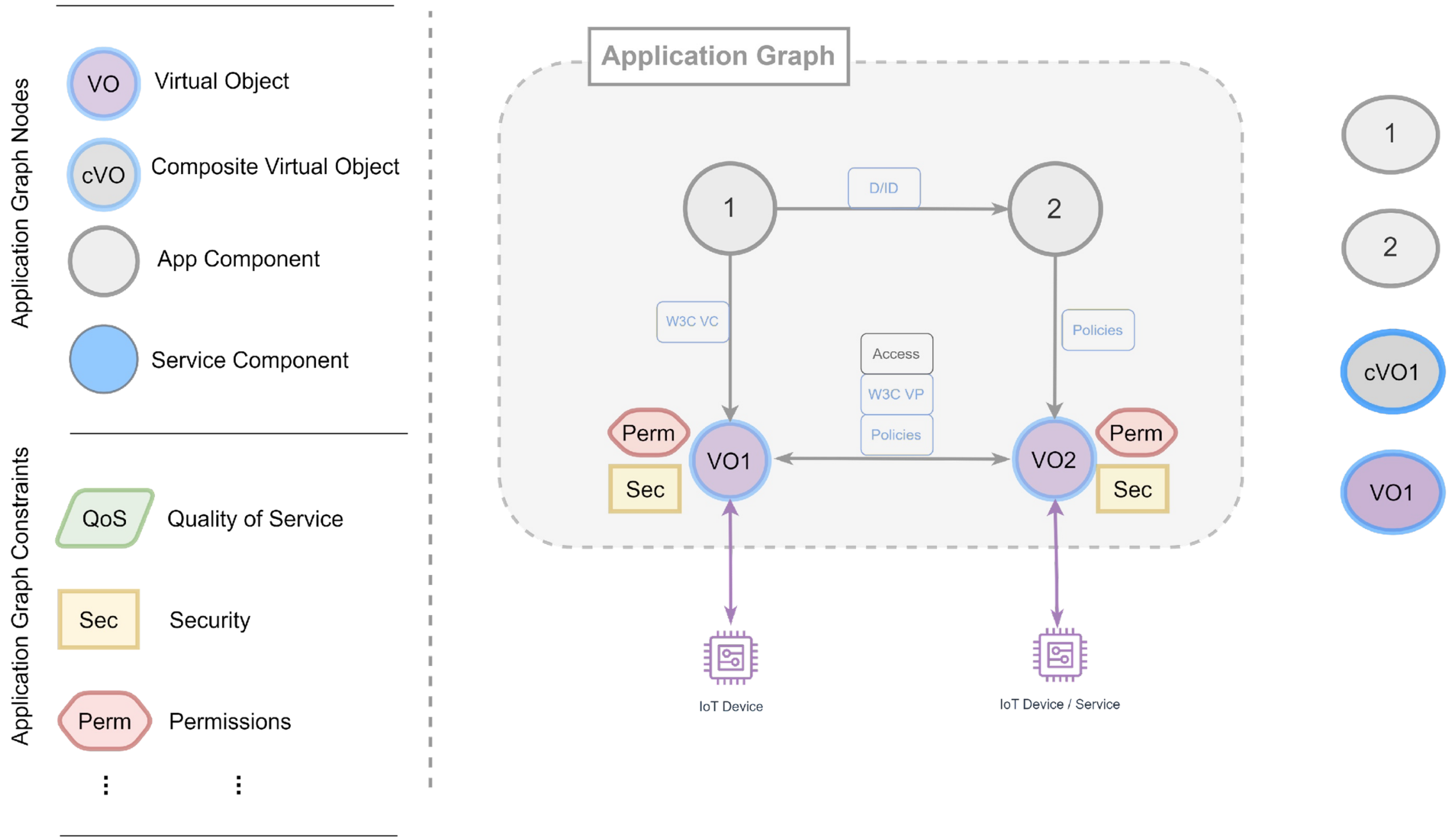
Use Case #3: Energy management in smart buildings/cities



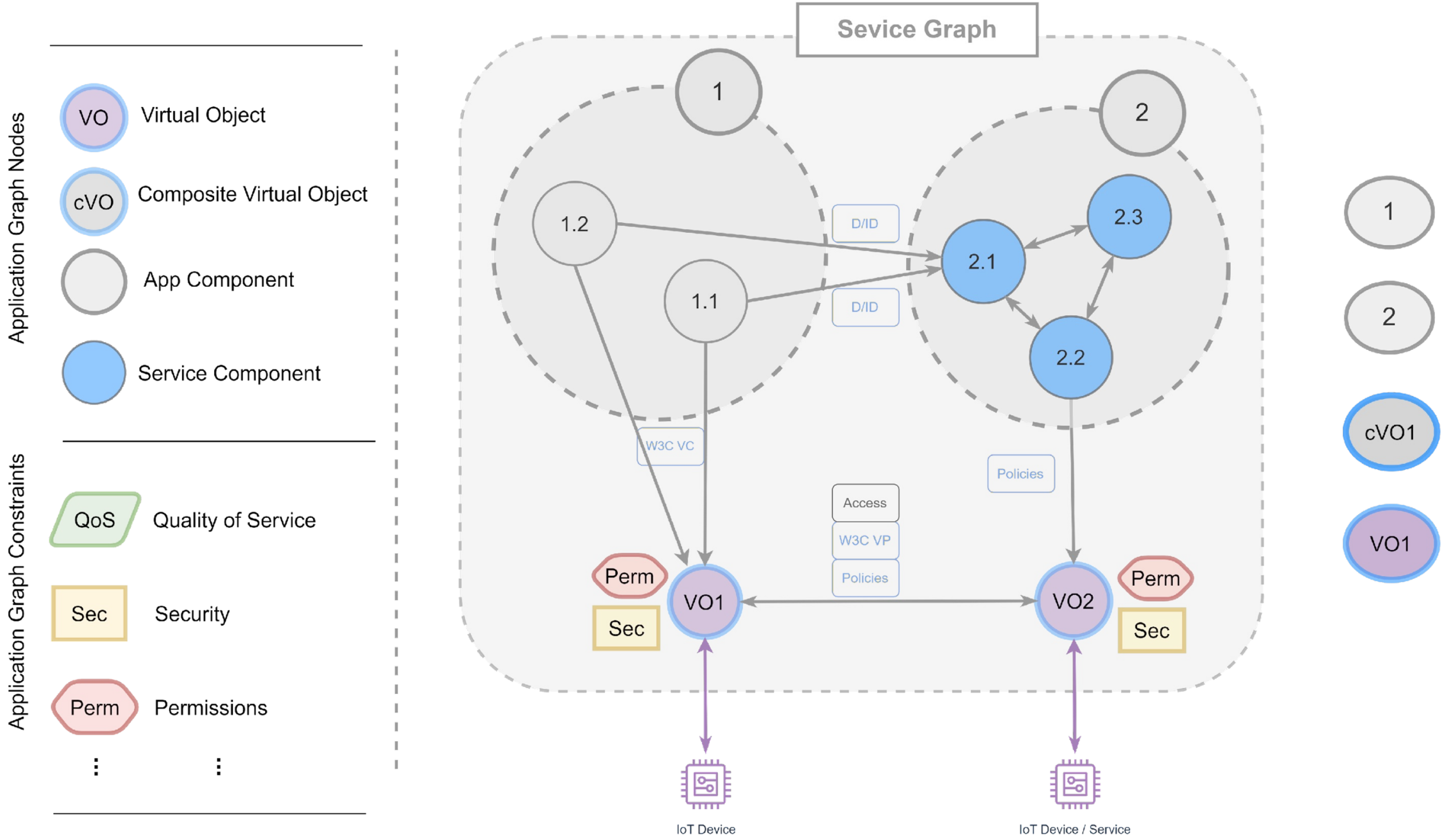
Application Scenario: DID and Verifiable Credentials



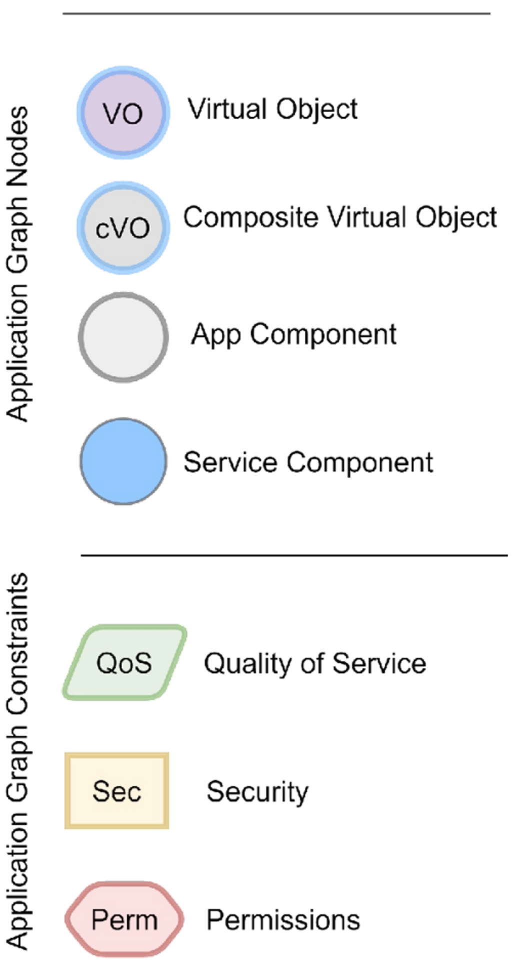
Application Scenario: DID and Verifiable Credentials (II)

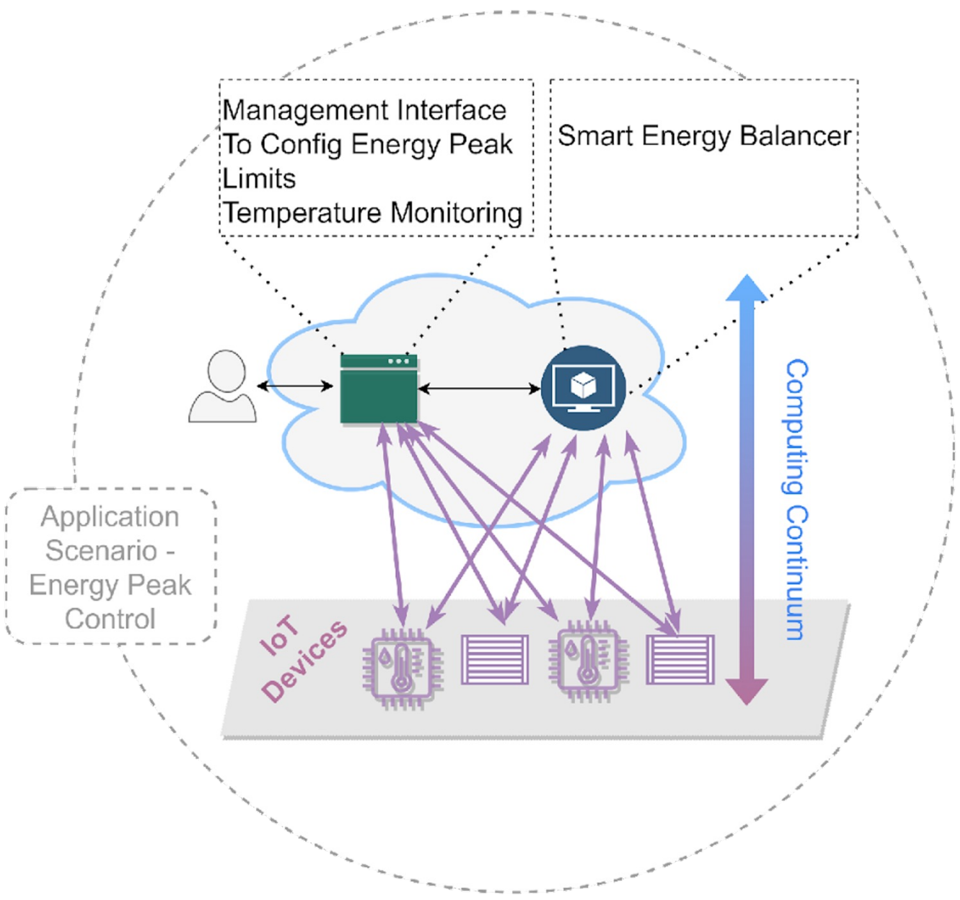


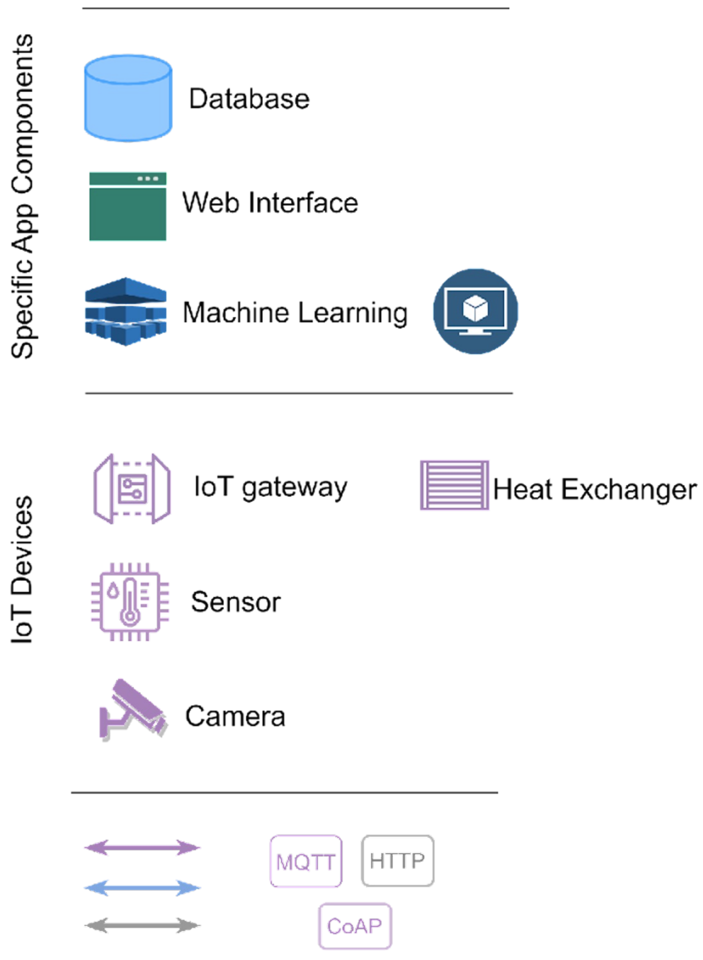
Application Scenario: DID and Verifiable Credentials (III)



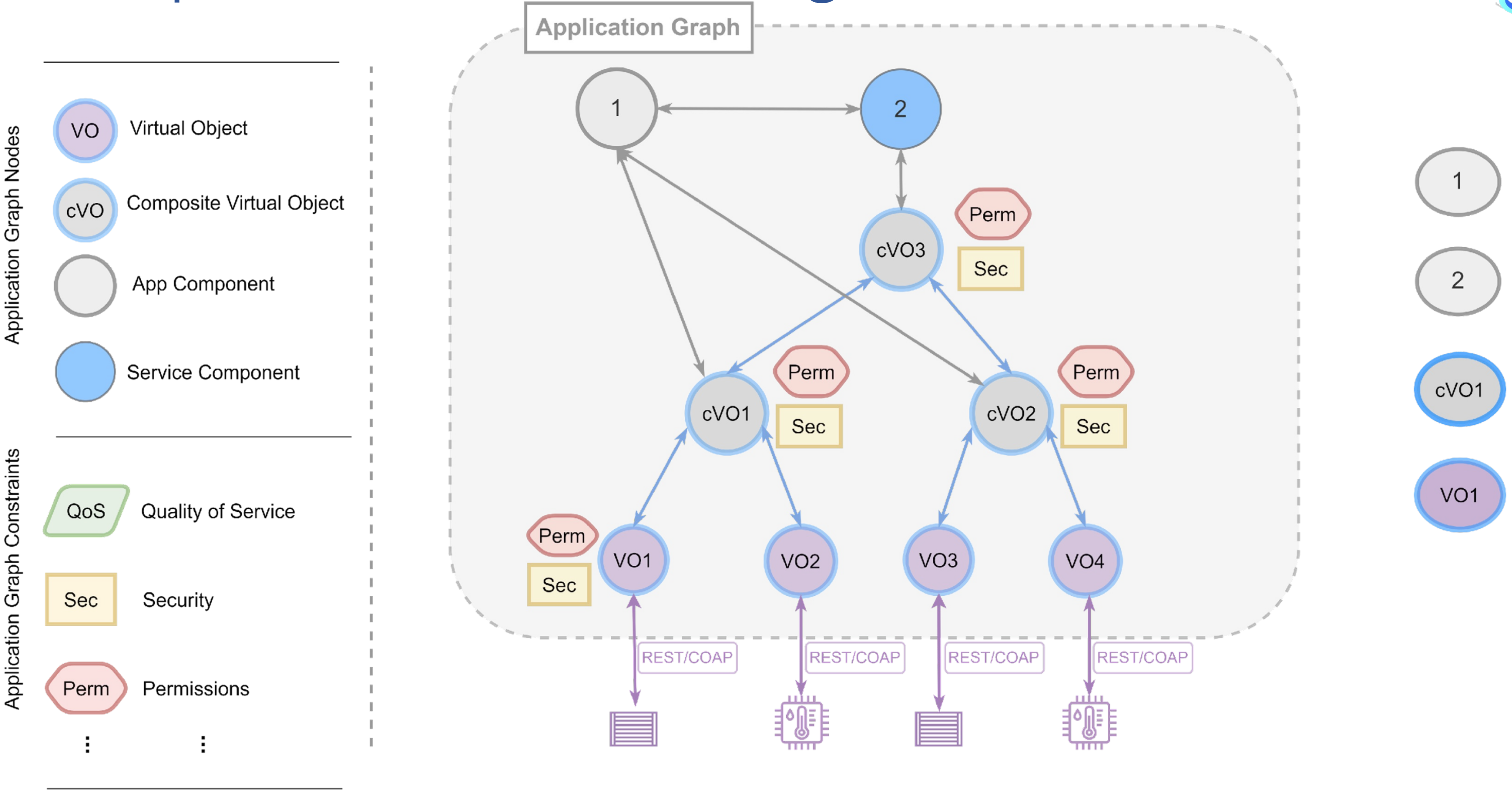
Application Scenario: Distributed complex decision making (I)



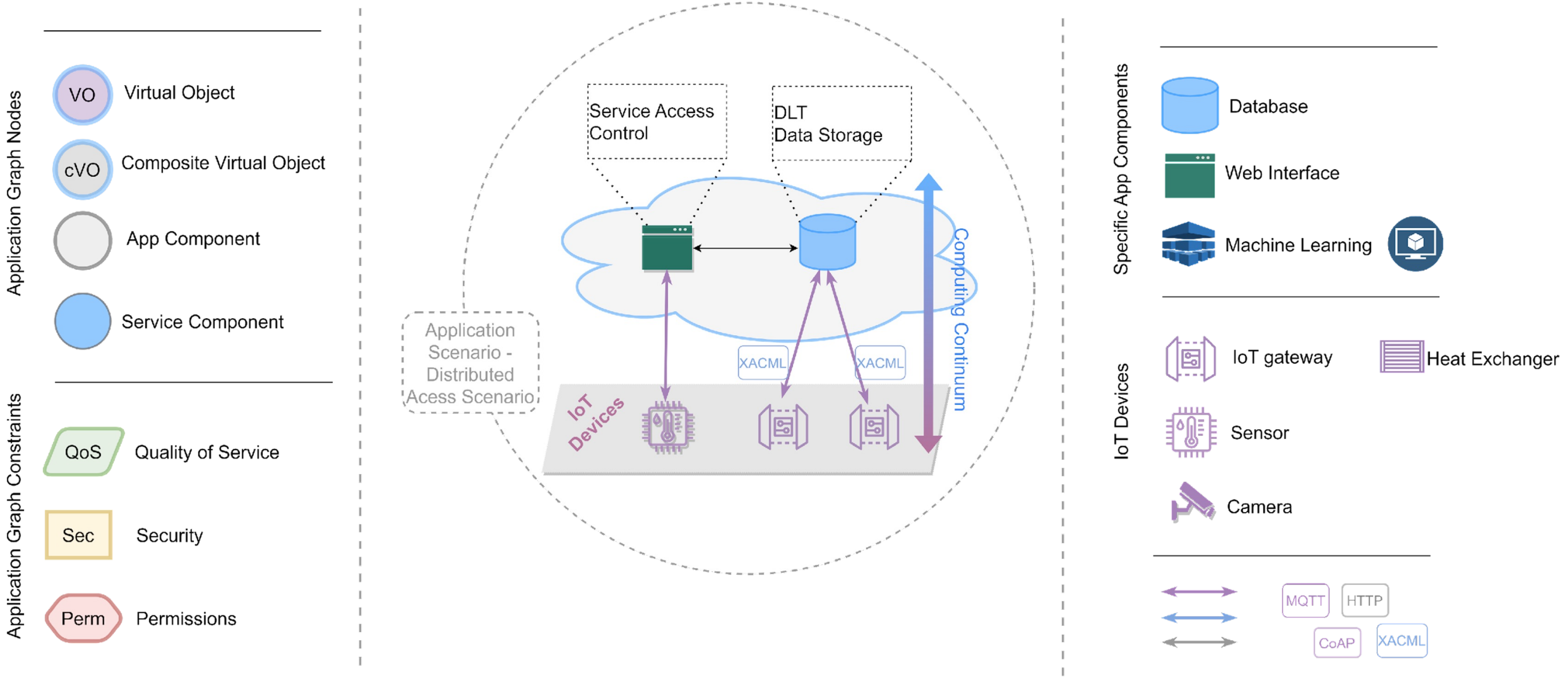




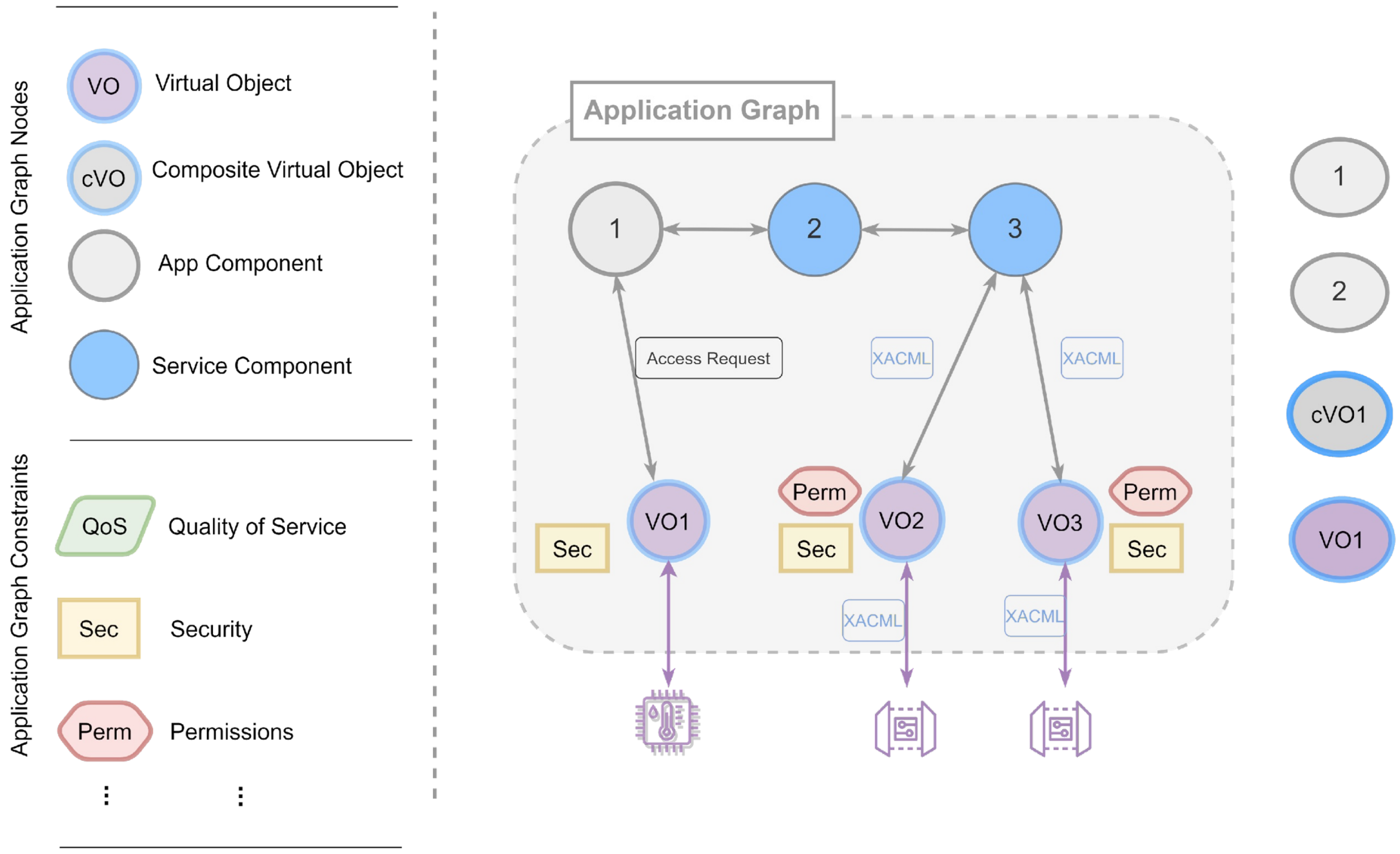
Application Scenario: Distributed complex decision making (II)



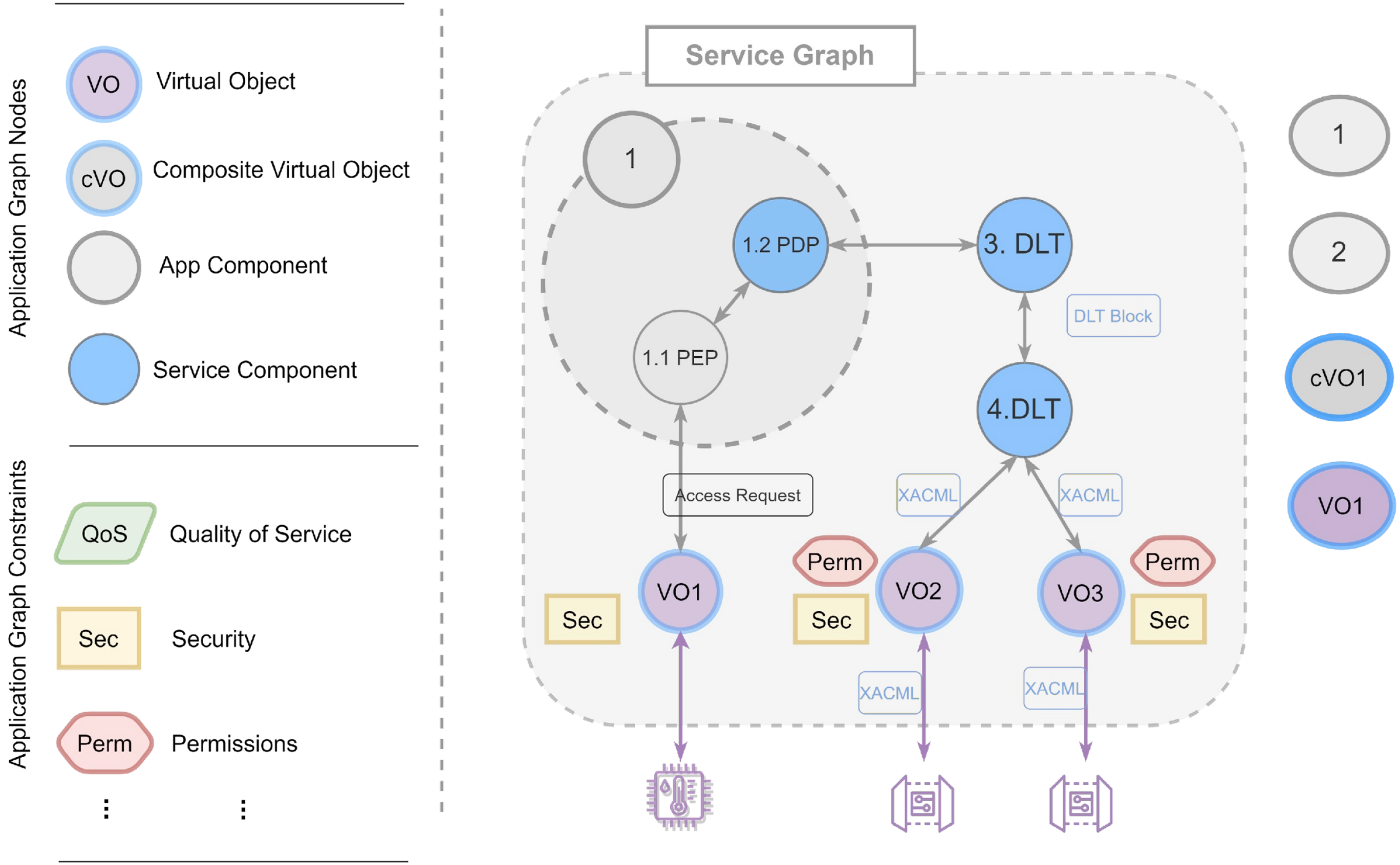
Application Scenario: Distributed Access Control (I)



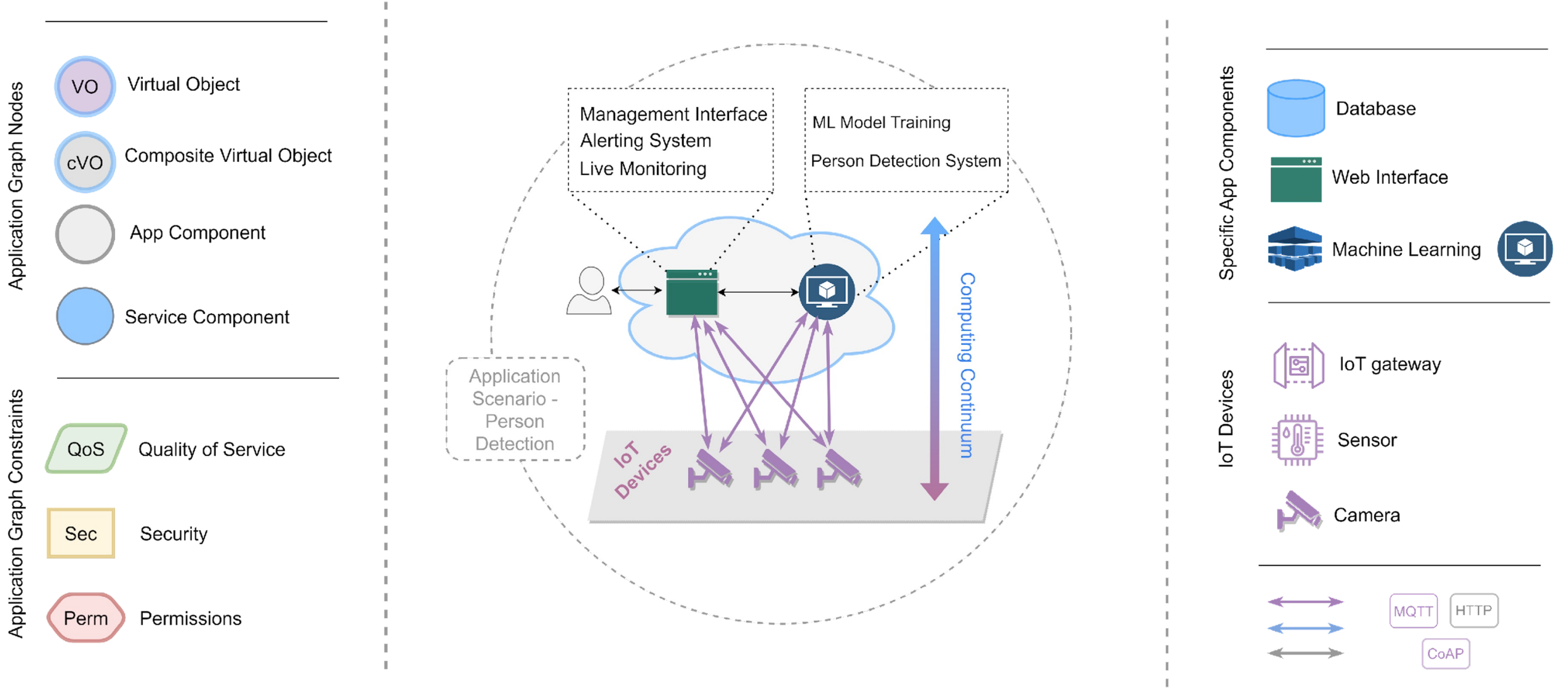
Application Scenario: Distributed Access Control (II)



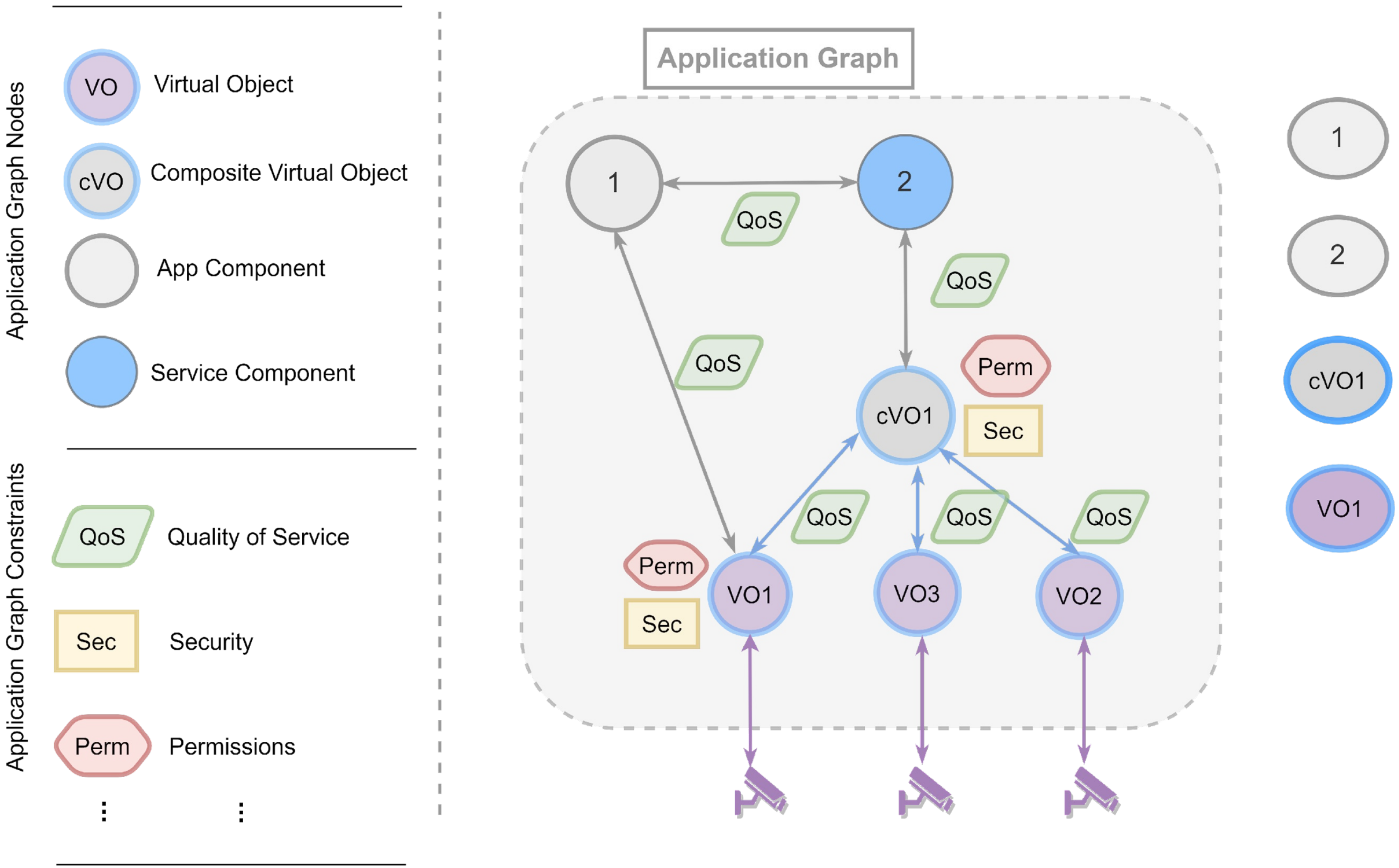
Application Scenario: Distributed Access Control (III/III)



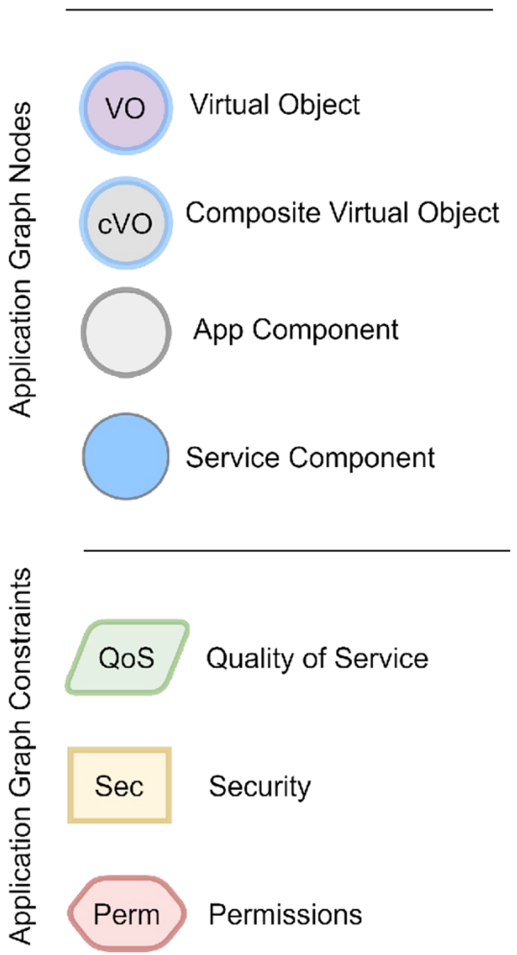
Application Scenario: Object/person detection through IA-assisted image processing (I)

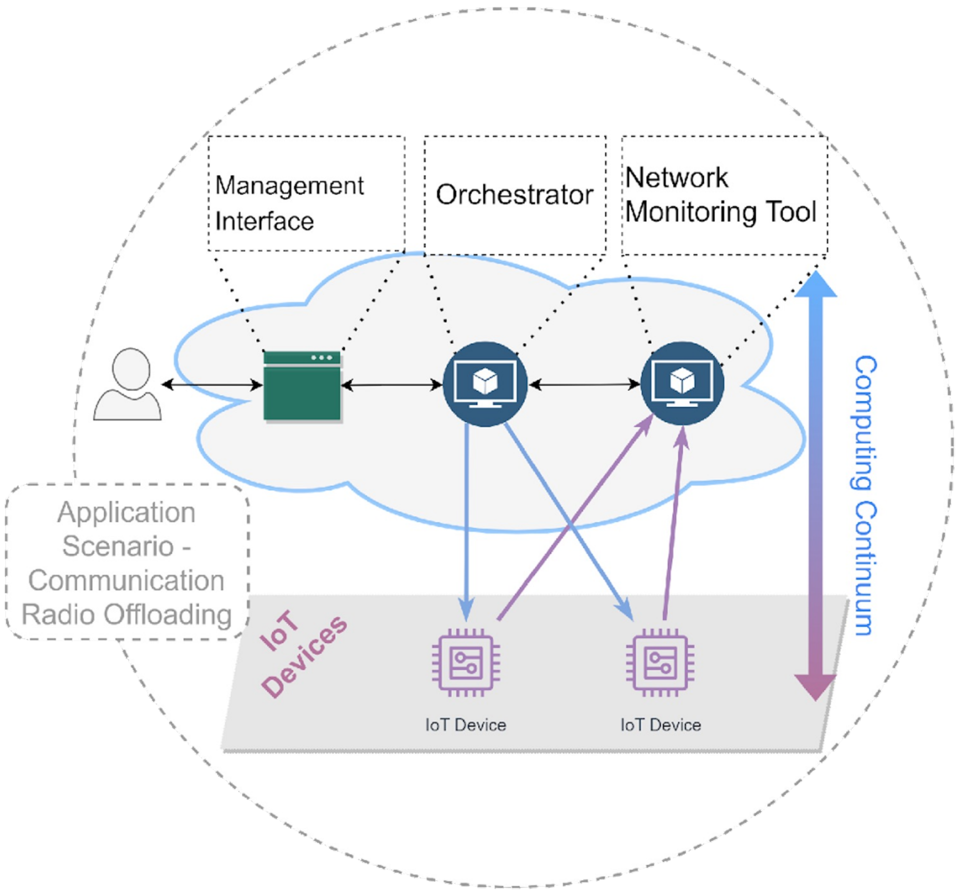


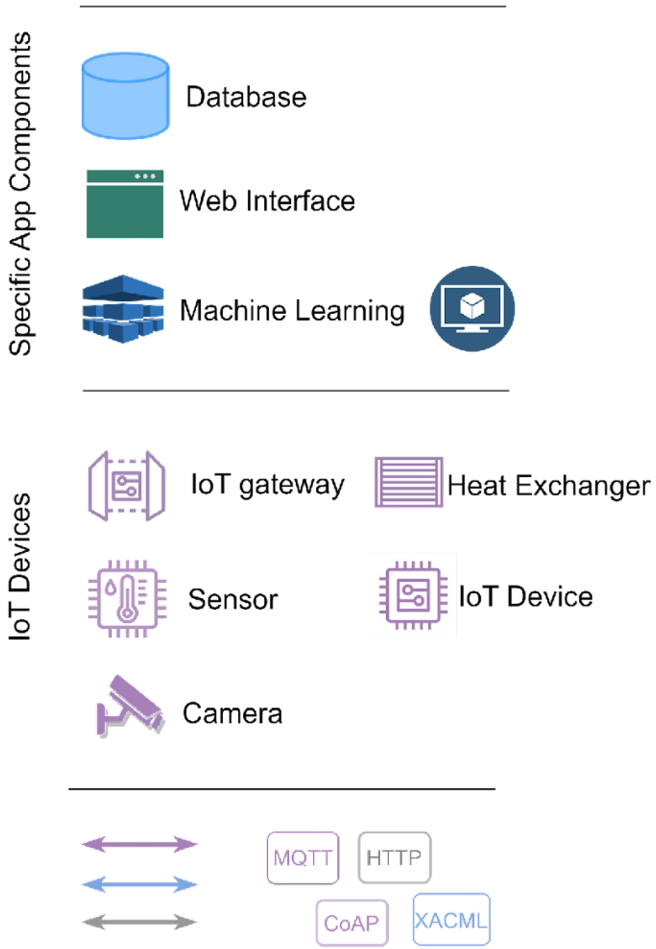
Application Scenario: Object/person detection through IA-assisted image processing (II)



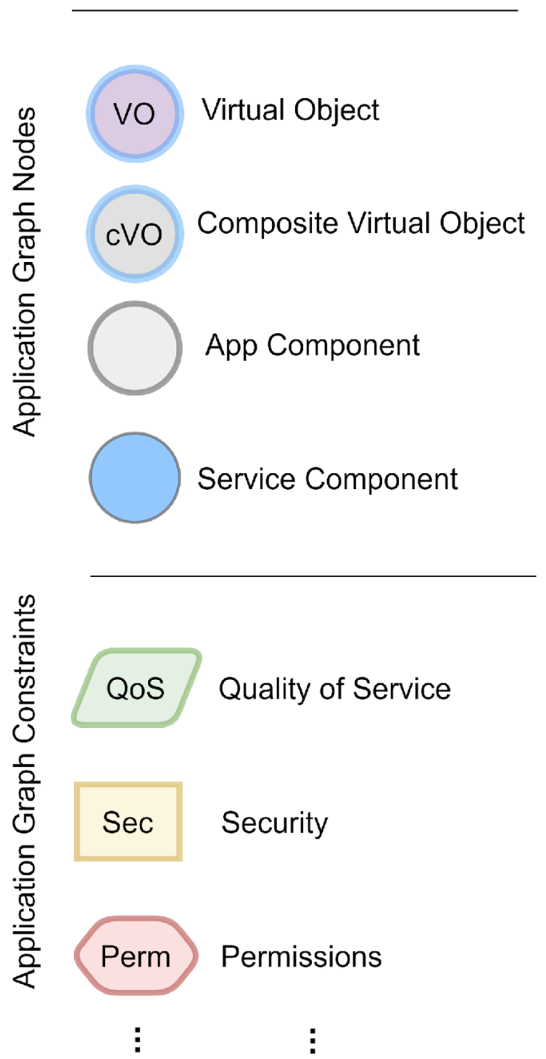
Application Scenario: Communication radio offloading (I)

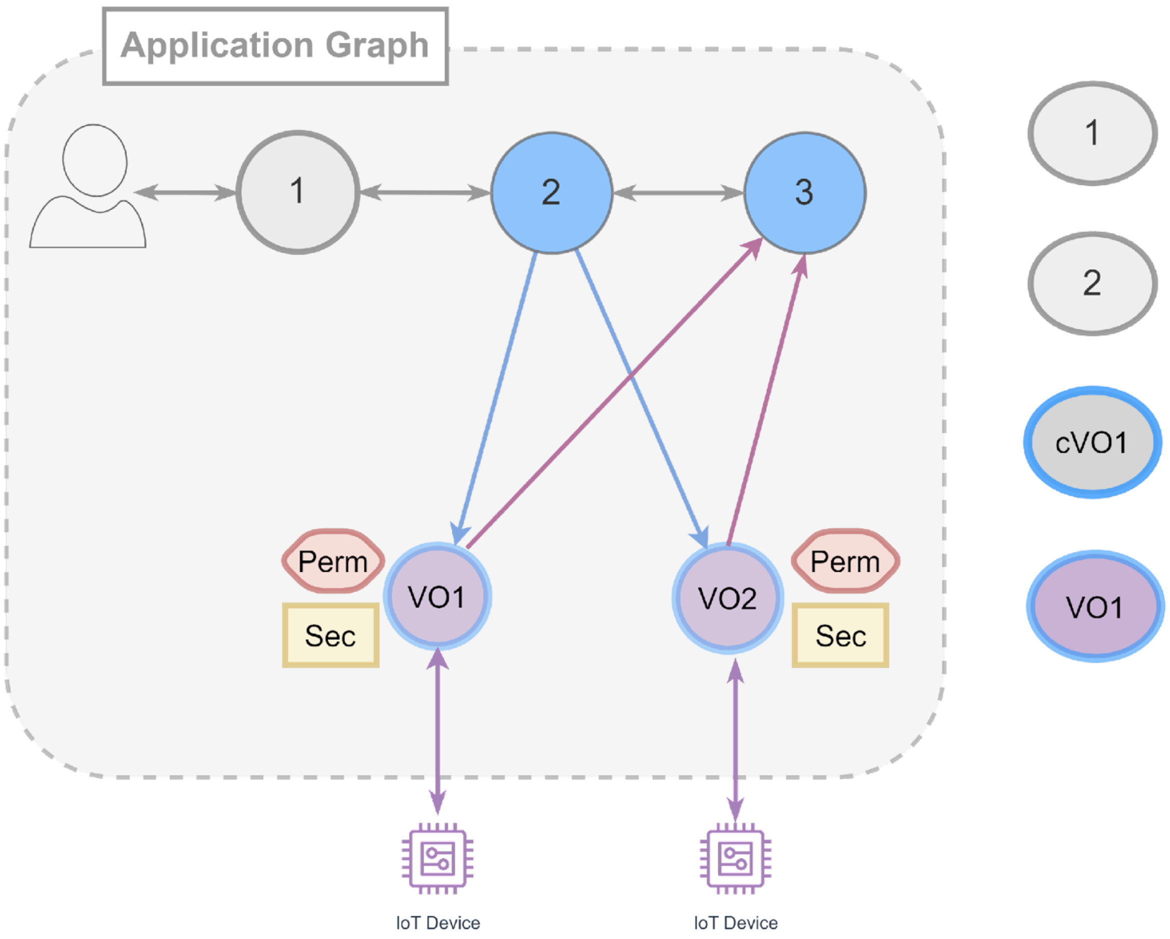




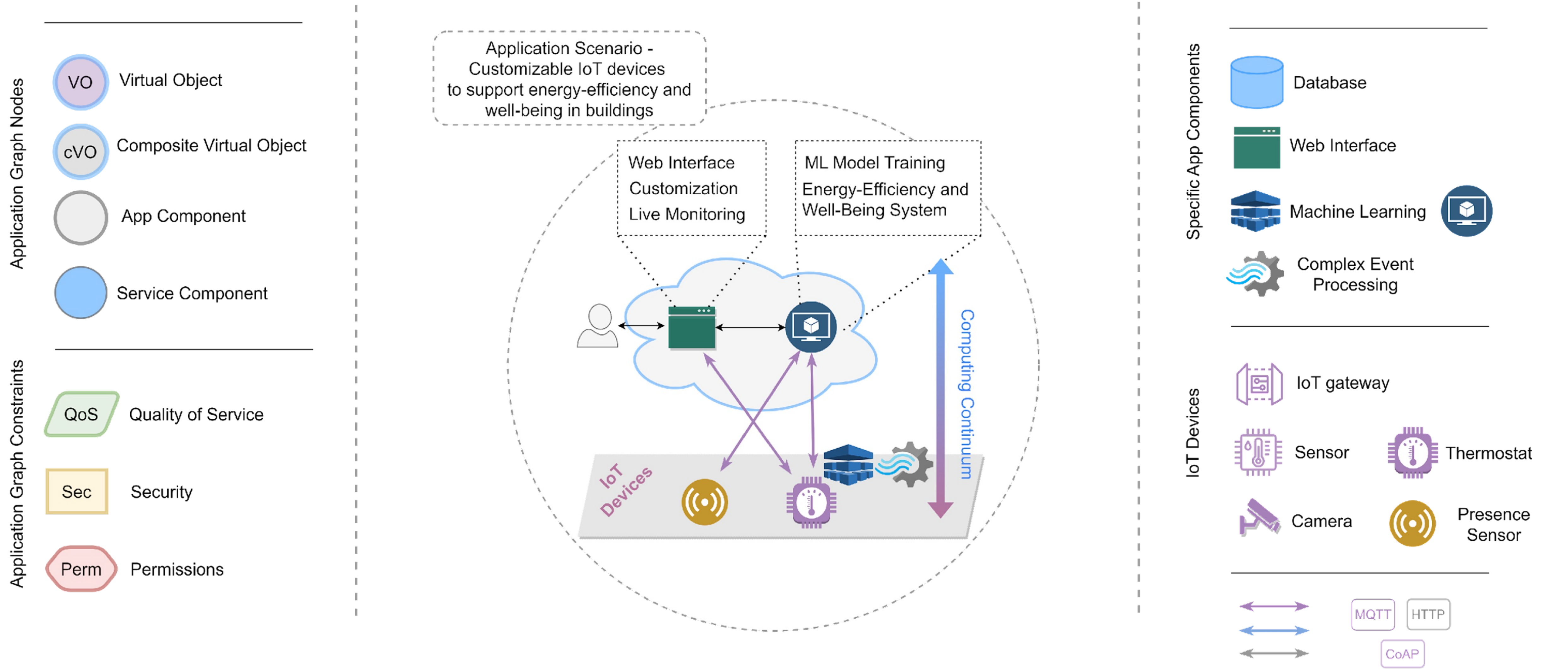


Application Scenario: Communication radio offloading (II)

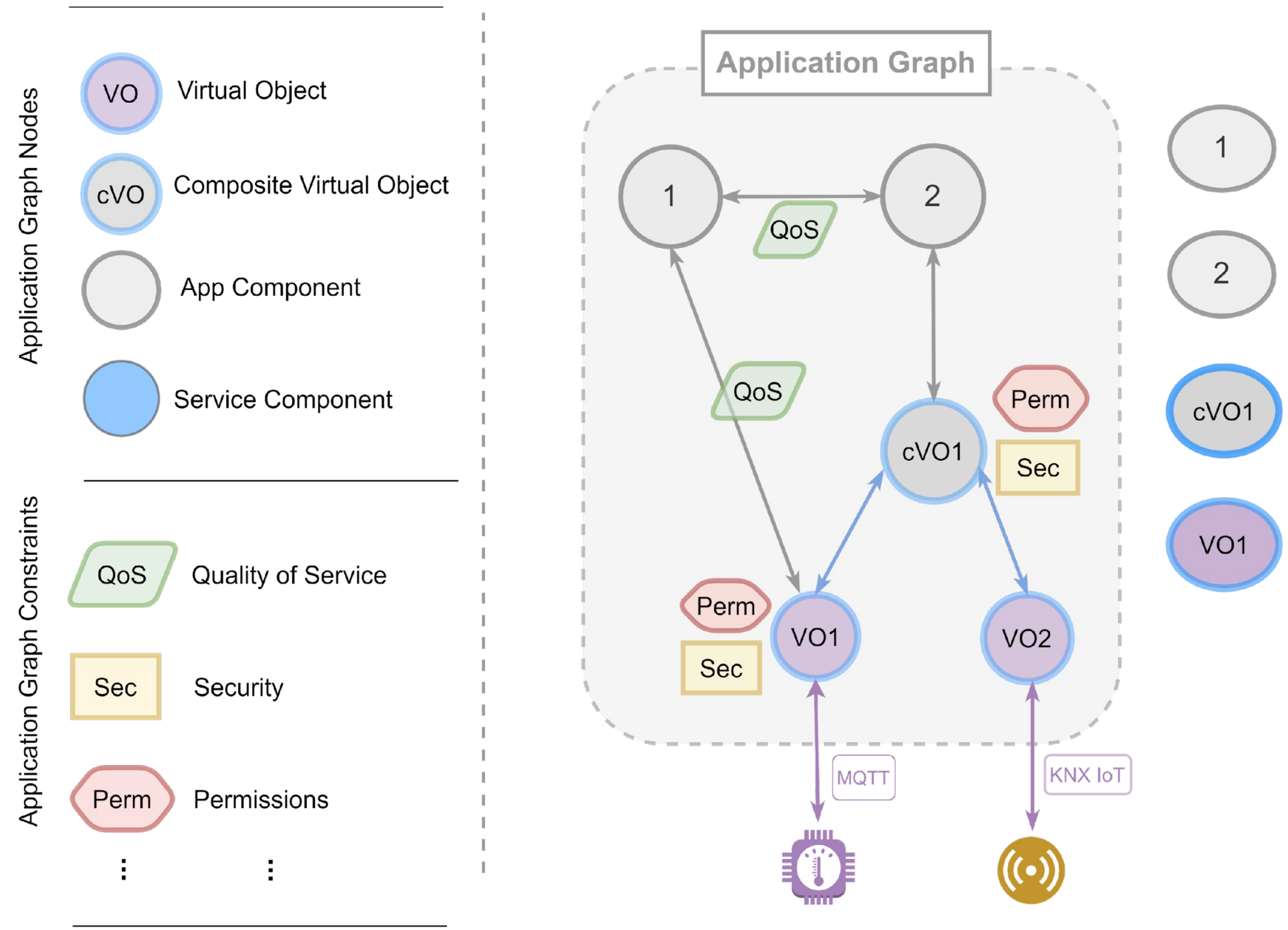




Application Scenario: Customizable IoT devices to support energy-efficient and well-being in buildings (I)



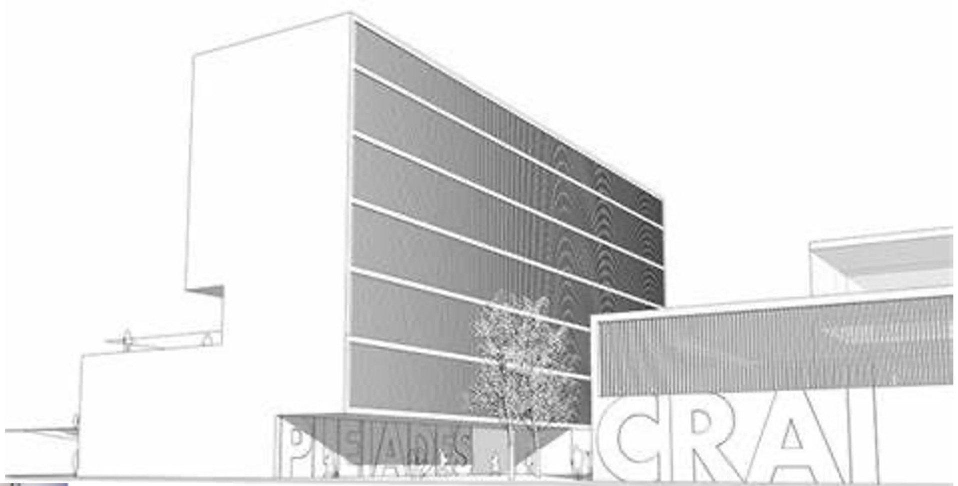
Application Scenario: Customizable IoT devices to support energy-efficient and well-being in buildings (II)

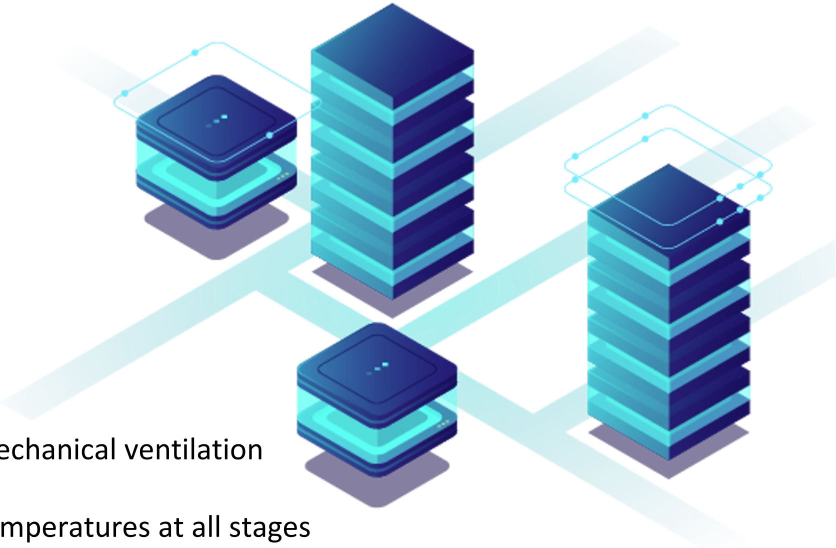


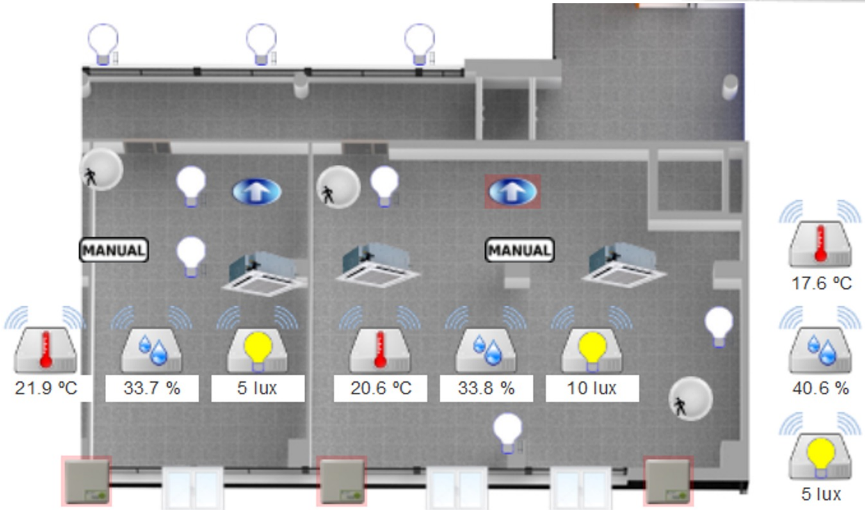
Use Case #3: Energy management in smart buildings/cities

Testbed: PEANA - Enhanced Platform for IoT Smart Cities and Buildings

- Temperature
- Humidity
- Light
- Air Quality Sensors (CO_2)
- Occupancy detection
- Smart Sockets
    - Energy consumption
    - Automated management







Mechanical ventilation

Temperatures at all stages

Pressure differences

Monitoring of power consumption

Actuation

Use Case #3: Energy management in smart buildings/cities

Equipment:

The existing IoT and Edge/Cloud computing infrastructure is mainly composed by wireless microcontroller IoT devices communicating with Edge nodes and cloud platforms.

The IoT constrained devices include:

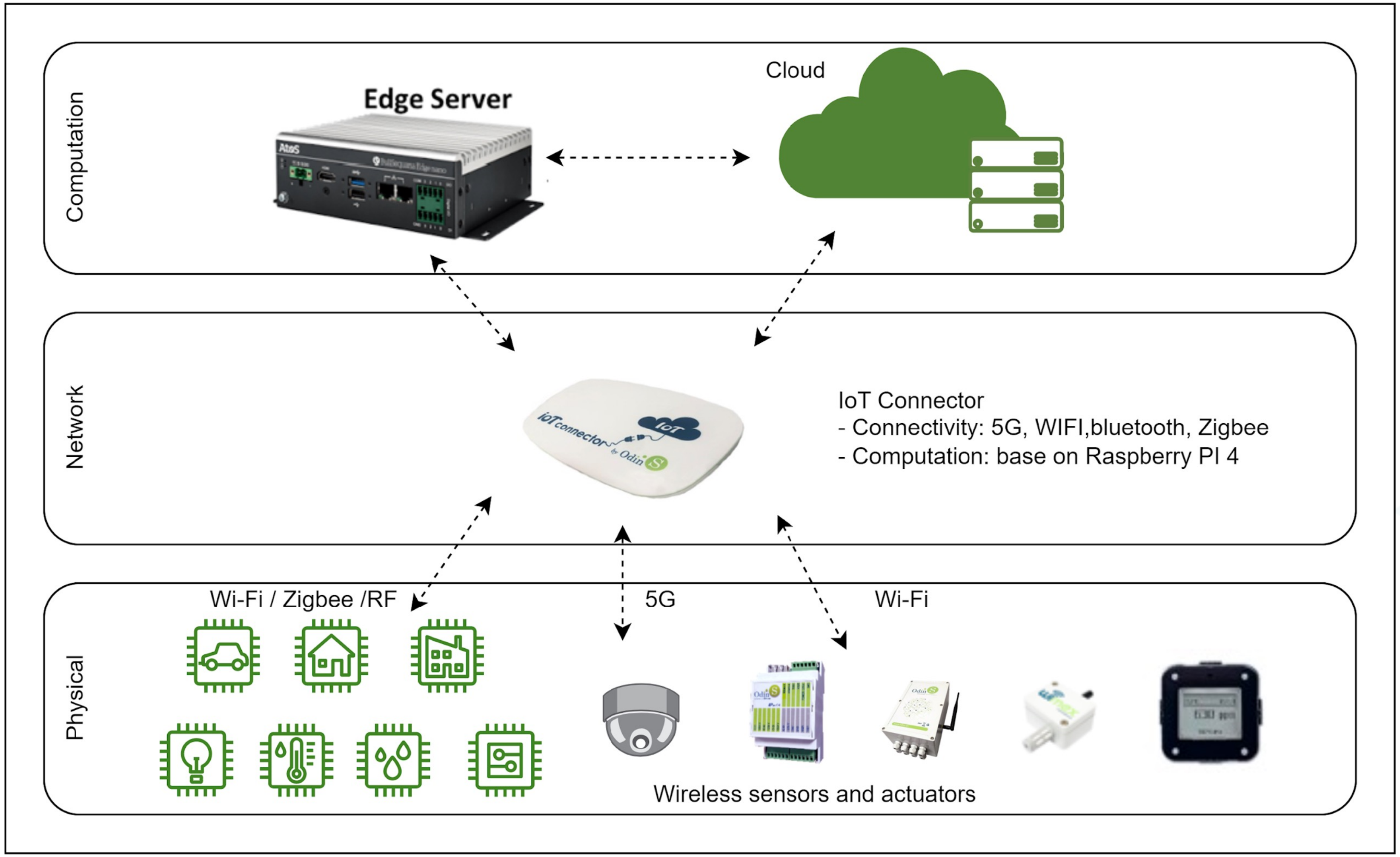
- sensors: temperature, humidity, CO_2, power meters , cameras
- actuators to control different environment parameters
  - Smart plugs, HVACs, network controllers, …

Used IoT constrained devices communication with edge nodes:

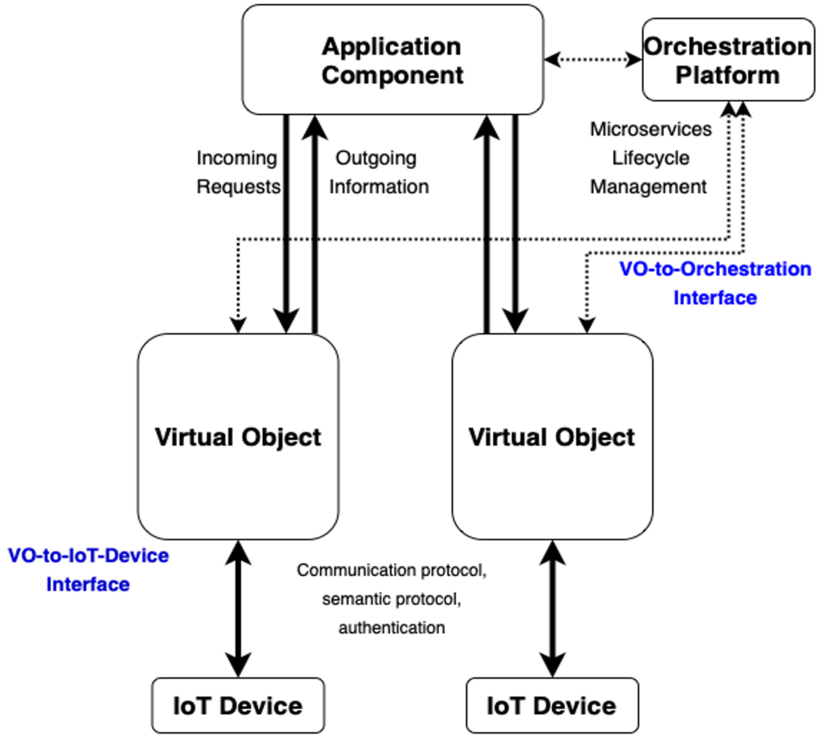
- Protocols: REST, COAP
- Wireless radio technologies: Wifi or NB-IoT.

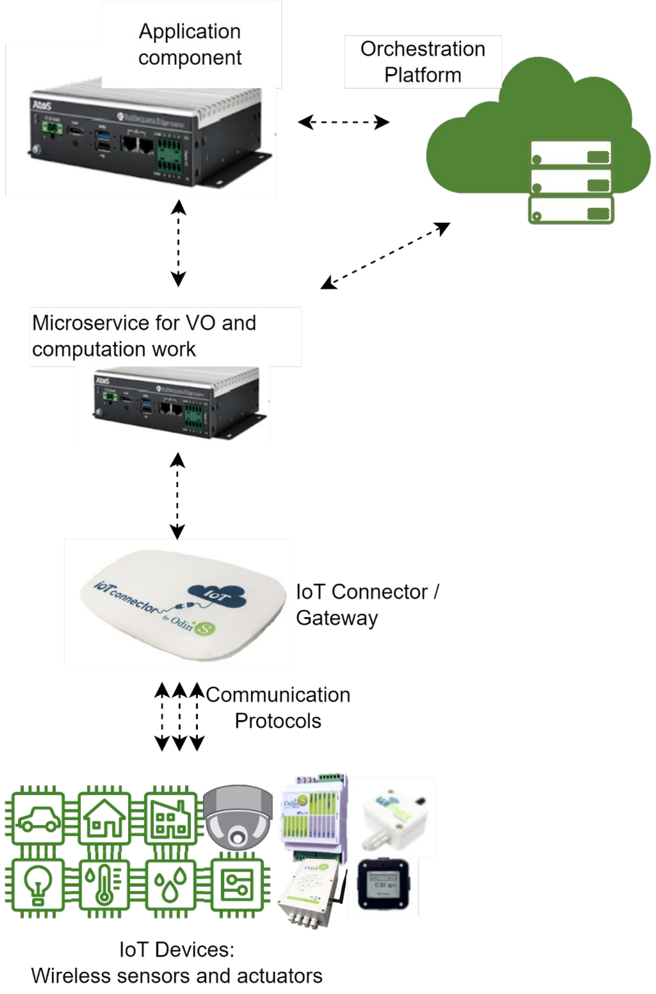
IoT communication gateway ODINS IoT Connector

Use Case #3: Devices at physical, networking and computation levels



Use Case #3: Virtual Object mapping





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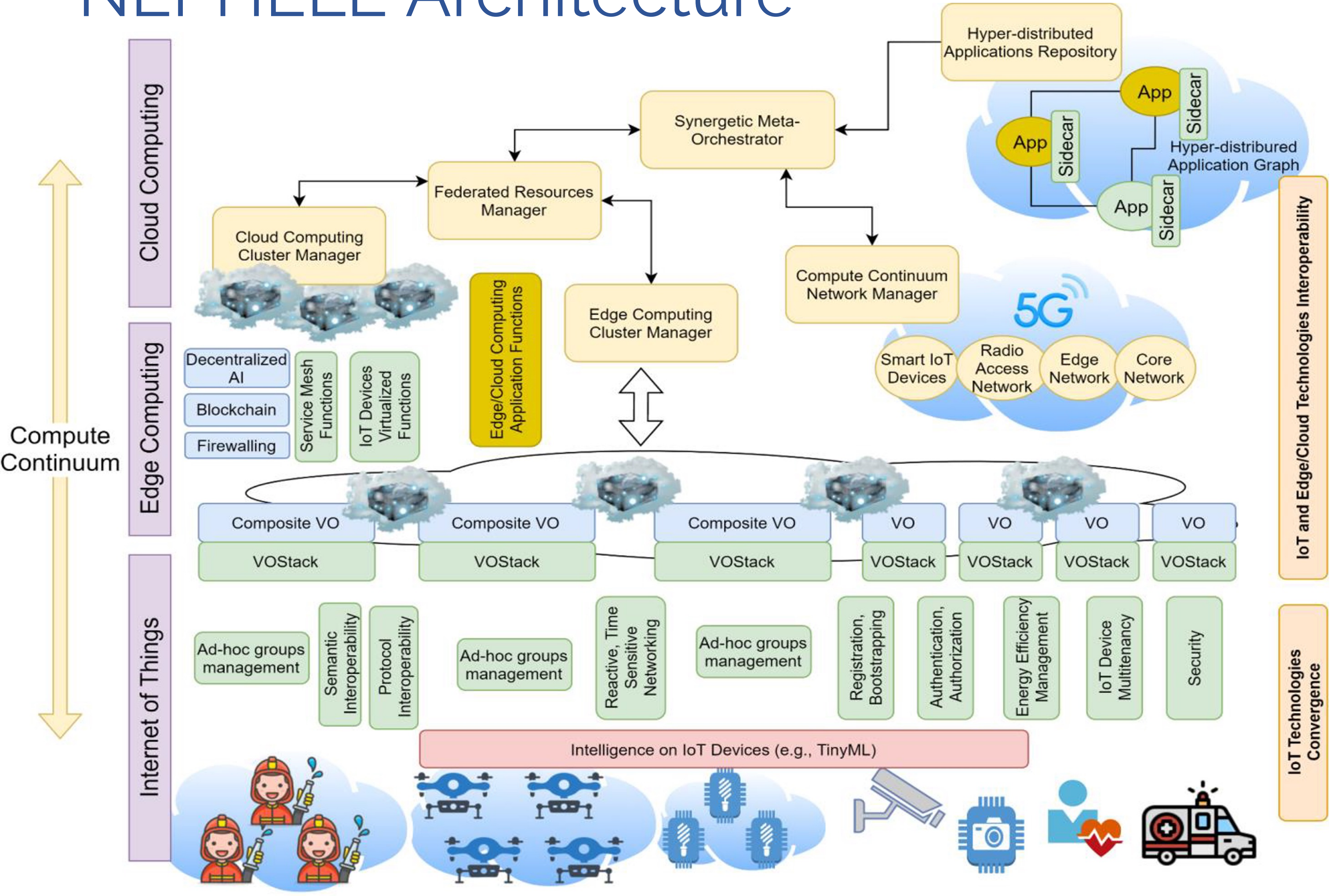
Thank you!

NEPHELE Architecture



Protocols, APIs Technologies

Synergetic Orchestration Management

Computing Orchestration: Kubernetes, NFV, MANO, OpenStack
Networking Orchestration: SDN, Slicing, ???
Communication Protocols: REST, JSON-LD, NTP, ???
Semantic and Data model: NGSI-LD + Web of Things????
Security: TLS, DLT, DID, XACML, DCapBAC, CP-ABE?????

Distributed Cloud servers
(ej. T4.5 Security servers, WP6 Application servers)

Network infrastructure
(SDN routers, switches, 5G)

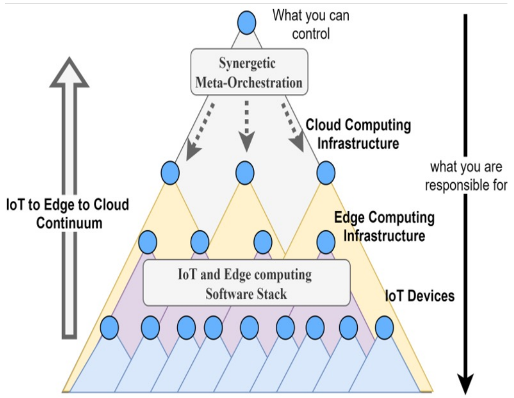
Computing Orchestration: Kubernetes, NFV
Communication Protocols: REST, JSON-LD
Semantic and Data model: NGSI-LD + Web of Things
Security: TLS, DLT, DID, XACML, DCapBAC, CP-ABE

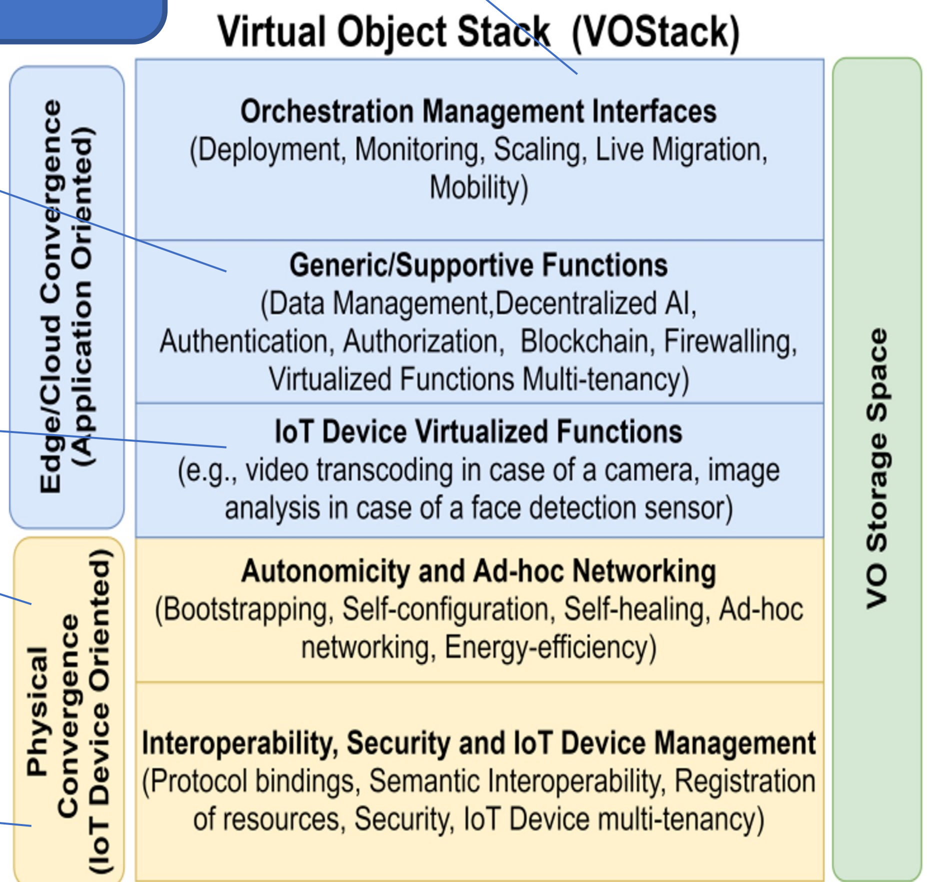
1. Dynamic Virtual Functions with Kubernetes NFV
2. Translating communication protocols, security, semantic & data models

VO/Edge nodes.
GB RAM/Disk. 64-bit CPU
(ej. RaspberryPI boards)

Communication Protocols: COAP, IP
Semantic and Data model: OMA LwM2M
Security: EDHOC, OSCORE, ACE Framework

IoT constrained devices
KB RAM/Flash. 16/32-bit CPU
(ej. Arduino boards)





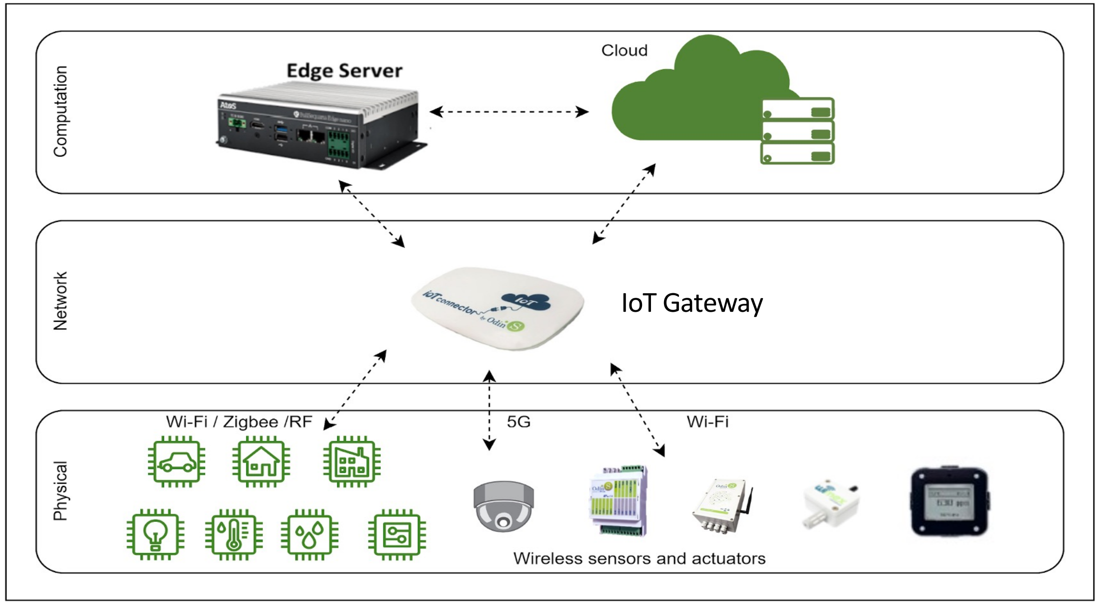
Use case of Energy Management in Smart Buildings

HORIZON call: HORIZON-CL4-2021-DATA-01-05 (RIA); Project NEPHELE 101070487; Period: 01-09-2022 to 31-08-2025; EC contribution 9 mill. EUR.

Concept:

Development & evaluation of NEPHELE technologies (Virtual Objects and Virtual Object Stack) for **intelligent monitoring and remote energy management in the continuum in the context of smart buildings**.

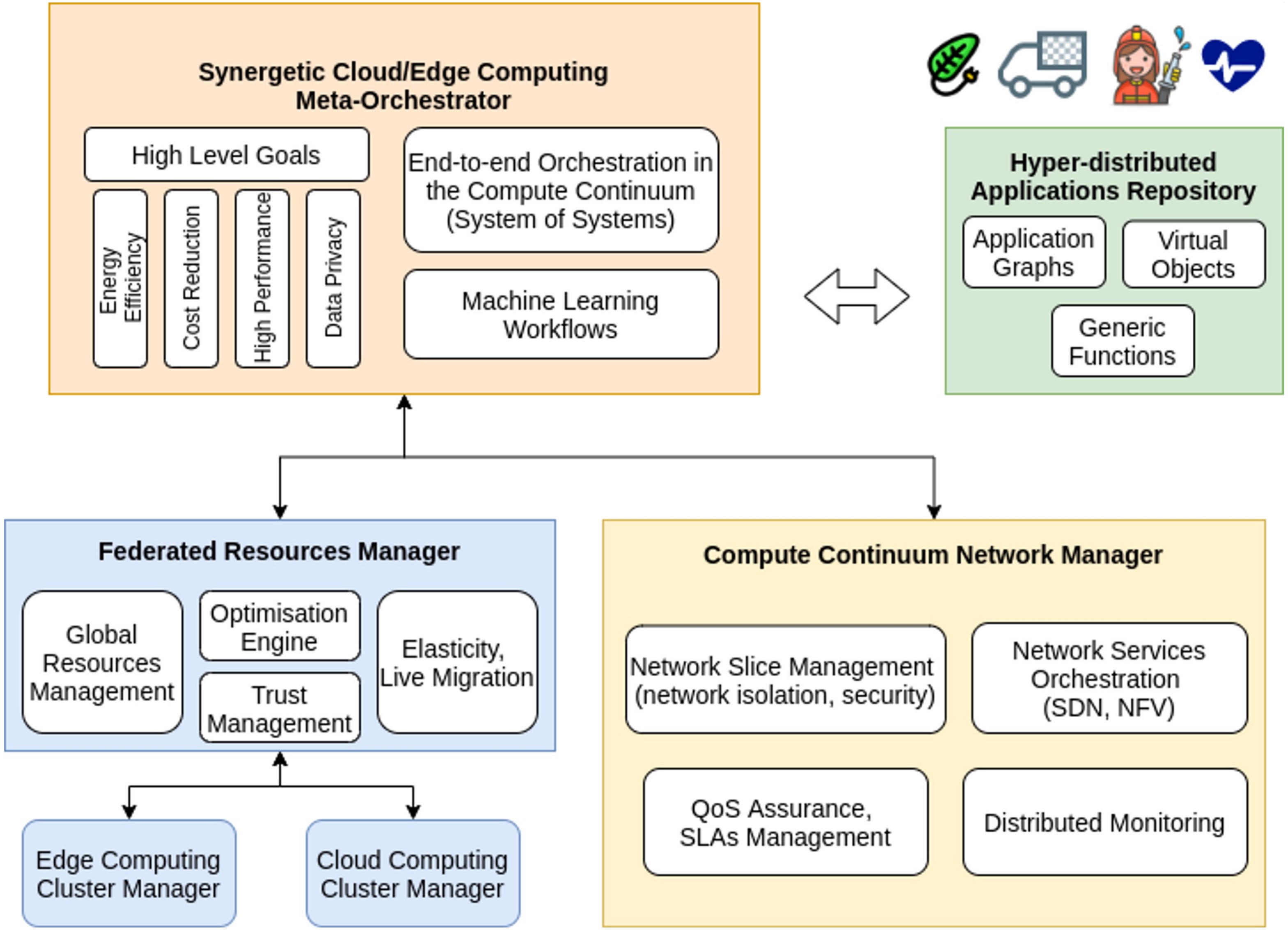
The objectives are developing applications to allow **energy-efficient control** actions, offering customized services to end-users and providing automation schema based on **real-time information**. The use case is also focus on video analysis for person and object detection.



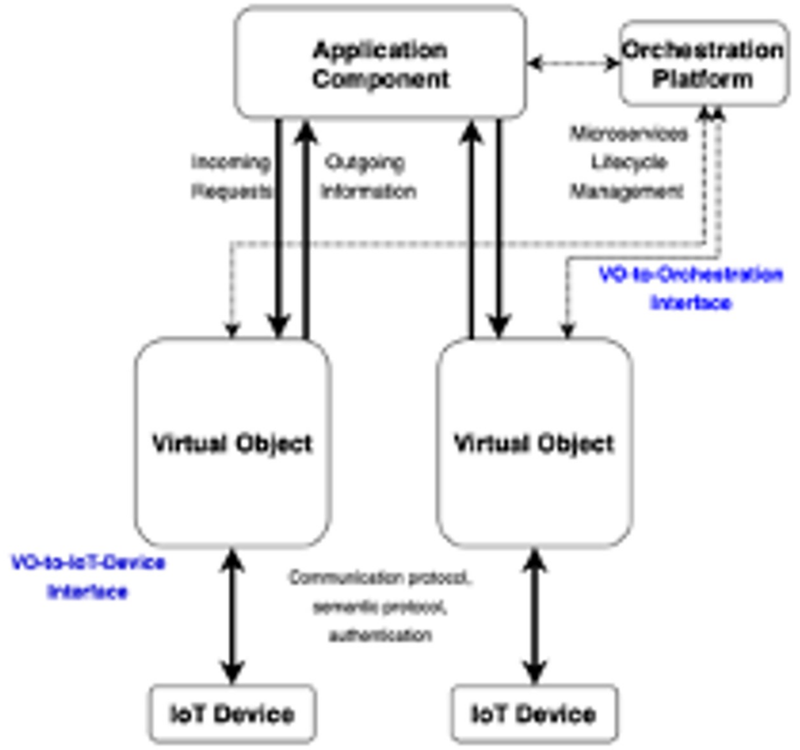
Benefits:

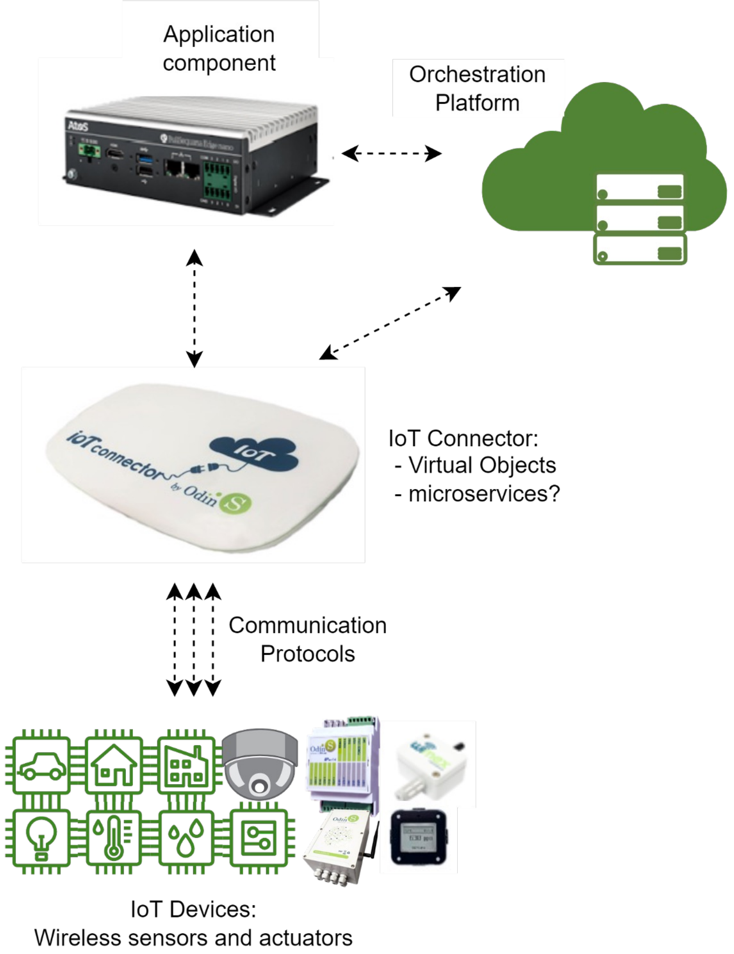
Real-time monitoring and data processing using **AI models** for decision making and control automation thanks to the aggregation of data from different sources. The use of virtual objects allows adding to constrained IoT devices, **advanced computing capabilities that allow complex cryptography, advanced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

Synergetic Orchestration Mechanisms



Use Case #3: Virtual Object mapping





Summary of the contributions (6/ 6)