This Communication is part of a project that has received funding from the European Union’s Horizon Europe research and innovation programme under grant agreement Nº 101069732.
The Concept

Energy Efficient, Health Safe and Sustainable Smart Buildings

Target

to minimize energy consumption and maximize health measures with smart-seating recommendations and automated housekeeping/building maintenance leveraging the aerOS edge-cloud continuum concepts

Powered by aerOS partners COSMOTE, UPV, NCSRD, FOGUS, INFOLYSIS
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- leveraging the aerOS edge-cloud continuum concepts

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**Context**

- By considering...
  - the metrics received by a vast range of sensors
  - historical data on energy consumption, CO2 emissions
  - historical data on employees' routine/preference

- **The aerOS pilot:**
  - Exploits AI to determine room health conditions and considers energy efficiency criteria to recommend the appropriate seating placement to the employee.
  - Uses the sensors data to actuate the ventilation, heating and air-condition systems as well as control luminosity.

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**Challenges & Innovations**

- **Energy Efficiency**
  - With multiple IOT vendors and solutions, tech integration, so that sensors, systems, analytics work in sync is cumbersome.
  - the aerOS architecture as a unique abstraction layer.

- **Sustainable Smart Buildings**
  - Distinctive infrastructure characteristics of each building rationalizing autonomous and decentralized decision-making.

- **Smart energy consumption calculation and forecast algorithms and systems**

- **5G SA IoT GWs with SDN, NFV, Network Apps Capabilities**

- **IoT automations**
  - swarm intelligence among the AEROS nodes to co-operate decentralized.

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*The Communication is part of a project that has received funding from the European Union’s Horizon Europe research and innovation programme under grant agreement 87106673.*
COSMOTE IoT Application Architecture

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aerOS Use Case 5 Application Architecture
IoT Application in aerOS architecture

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**Health Index (Hi)**

What do we consider a healthy office space?

**Thermal Comfort**
- Temperature: 19 °C - 25 °C
- Humidity: 30% - 50%

**Air Quality**
- CO: 30 ppm (1h)
- CO2: < 1350 ppm
- Particulate Matter (PM2.5): 25 mg/m^3 (24h)

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**Future**

- **Time Series F. Model** → **Temperature**
- **Time Series F. Model** → **Humidity**
- **Time Series F. Model** → **CO**
- **Time Series F. Model** → **CO2**
- **Time Series F. Model** → **Particulate Matter**
- **Time Series F. Model** → **Energy Consumption**

**Control HVAC**
- Heating
- Ventilation
- Air Conditioning

**Ruled Based Approach**

**Threshold**

**Healthy Office**

**Energy Efficiency**
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aerOS Pilot

High Performance Computing on Edge

KPIs & Evaluation Framework

Electrum Induce Ltd. September 2023
Pilot Project Description (DER Industrial Site)

The Electrum’s deployment of the aerOS pilot project is based on an advanced IT solution designed for distributed energy resources that allows for increasing energy efficiency and ensuring continuity in the cyber-secure data stream from IoT (sensors) through Edge (edge computers, data concentrators) to the Cloud.

The aim of the project is to examine metrics related to the energy efficiency and computational performance of a solution in which continuous machine learning processes use the computing power of an edge device installed directly on premises. In order to test the metrics/KPIs in the pilot, it is necessary to transfer data inference of the ESS Scheduler application to the edge computer with a neural network accelerator, such as the Electrum’s Industrial AI Edge Computer.
Pilot Project Diagram (DER Industrial Site)

Two Locations:
- AluFrost industrial / manufacturing facility (PV+BESS)
- Electrum HQ (hybrid DER)

Substation(s) RN-W 400V AC

BESS CONTROLLER

EMACS Telemetry Controller
AI Edge Computer (Orin NX)

EMACS VPP runtimes
ESS Scheduler Inference
aerOS runtimes

ENERGY METERS

- Grid Power
- PV Generation
- Energy Consumers

Li-ion
battery
modules

Li-Ion battery modules

Modbus TCP/IP

IP SEC LTE GSM

Substation(s) RN-W 400V AC

BESS CONTROLLER

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EMACS VPP runtimes
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ENERGY METERS

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Li-ion
battery
modules
*Evaluation Flow Diagram*

- **aerOS stack**
  - NGSI-LD API
  - Kafka
  - Compute Fabric
  - EMACS API
  - ESS Scheduler

- **EMACS stack**
  - DCGM monitoring
  - Health & performance
  - HPC monitoring stack

- **data stream continuum**

- **Location Context Broker**
  - **Alert:** container temperature increasing
  - **Orchestration Schedule:** Container temperature predictions
  - **Orchestration Schedule:** Bandwidth limitations

- **Real time data feed for MLOps (e.g. ESS Scheduler)**
  - Distributed event store and stream-processing platform

- **MLOps Inference on-premises for VPP SaaS**
  - Grafana dashboard & reports

- **Docker microk8s ML services for Yield Predictions, Consumption Efficiency Recommenders, ESS Scheduler, etc.**

In the rapidly evolving landscape of IoT-Edge-Cloud infrastructure, the development and deployment of meta operating systems play a pivotal role in ensuring efficiency, scalability, and resilience. To assess the effectiveness and suitability of these meta operating systems, a comprehensive evaluation framework is essential. This framework is designed to rigorously test and measure multiple technical, economical, and social key performance indicators (KPIs) to ensure that the meta operating system aligns with the evolving needs of modern distributed IoT-Edge-Cloud ecosystems.

The evaluation framework aims to achieve the following objectives:

**Technical Evaluation:**
- **Scalability**: Assess the system's ability to scale horizontally and vertically to accommodate a growing number of IoT devices and edge nodes.
- **Reliability**: Evaluate the system's uptime, fault tolerance, and failure recovery mechanisms.
- **Security**: Analyze the security measures in place to protect against cyber threats and data breaches.
- **Latency and Responsiveness**: Measure the response time and latency for data processing and communication within the infrastructure.
- **Interoperability**: Assess compatibility with various IoT devices, edge devices, and cloud platforms.
- **Resource Efficiency**: Evaluate resource utilization, including CPU, memory, and network bandwidth.

**Economic Evaluation:**
- **Total Cost of Ownership (TCO)**: Calculate the overall cost of implementing and maintaining the meta operating system, including hardware, software, and operational expenses.
- **ROI and Cost Savings**: Assess the return on investment and potential cost savings achieved through the deployment of the meta operating system.
- **Scalability Costs**: Analyze how costs scale as the infrastructure expands.
- **Resource Optimization**: Measure resource utilization efficiency to reduce unnecessary expenses.

**Social Evaluation:**
- **Usability**: Evaluate the user-friendliness of the system, including configuration, monitoring, and maintenance.
- **Accessibility**: Assess the system's inclusivity and its ability to serve diverse user groups.
- **Community Engagement**: Gauge the level of community support, open-source contributions, and collaboration around the meta operating system.
- **Environmental Impact**: Analyze the environmental sustainability of the infrastructure and the meta operating system's contributions to reducing energy consumption.
- **Ethical Considerations**: Examine ethical aspects such as data privacy, consent, and responsible AI integration.

Methodology:
The evaluation framework employs a combination of quantitative and qualitative methods, including benchmarking, simulation, surveys, and real-world testing. It incorporates both laboratory-based assessments and field trials to ensure a comprehensive evaluation.

Key Performance Indicators (KPIs):
The evaluation framework defines a set of KPIs specific to each objective, allowing for precise measurement and comparison of meta operating systems. These KPIs are regularly updated to reflect the evolving needs of the industry.

Reporting and Decision-Making:
The results of the evaluation are presented in a clear and concise report that includes recommendations for improvement or adoption. Stakeholders can use this information to make informed decisions regarding the deployment and optimization of meta operating systems in their IoT-Edge-Cloud infrastructure.

Conclusion:
The Comprehensive Evaluation Framework for Meta Operating Systems in Distributed IoT-Edge-Cloud Infrastructure is a critical tool for assessing the technical, economic, and social viability of these systems. It ensures that meta operating systems not only meet technical requirements but also contribute positively to the broader ecosystem while being economically viable and socially responsible.
## Key Performance Indicators

<table>
<thead>
<tr>
<th>AREA</th>
<th>INDICATOR</th>
<th>DESCRIPTION</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td>Healthchecks</td>
<td>System uptime [%], Cron Job Monitoring, Microservice Readiness Scans</td>
<td>%</td>
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<tr>
<td></td>
<td>Latency</td>
<td>Average response time (ping) between IoT and Edge vs IoT and Cloud</td>
<td>ms</td>
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<tr>
<td></td>
<td>HPC Performance</td>
<td>PFLOP/s constant measurement (DCGM), SQL DB for avg. 1hrs</td>
<td>PetaFlops</td>
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<tr>
<td>Economical</td>
<td>Energy Savings</td>
<td>Energy consumed by IoT-Edge-Cloud GPU system vs energy consumed by IoT-Cloud</td>
<td>kWh, %</td>
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<tr>
<td></td>
<td>Bandwith Savings</td>
<td>MLOps data transfer: Edge-Cloud vs IoT-Cloud</td>
<td>Mb, %</td>
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<td>CAPEX Savings</td>
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<td>TBD</td>
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<tr>
<td>Social / Safety</td>
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