Keywords: #energymanagement, #realtimeoccupancy, #buildings, #datasecurity, #roomoccupancy

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From Vision to Impact

MetaOS Project

Optimising Energy Management with Predictive IoT Devices: Interoperable Solutions for Real-time Room Occupancy

Background

The operations of buildings account for 30% of global energy consumption and 26% of global energy-related emissions. A significant contributor to this consumption is HVAC systems, which are critical for providing temperature control and indoor air quality but are known to be inefficient.

The Company

Siemens AG is a global powerhouse in electronics and electrical engineering. Operating in the fields of automation, digitalisation and electrification, Siemens holds leading market positions in all its business areas. The company has roughly 320,000 employees worldwide working to develop and manufacture products, design and install complex systems and projects, and tailor a wide range of solutions for individual requirements. For 176 years, Siemens stands for technological excellence, innovation, quality, reliability and internationality. Siemens has a strong portfolio in Building Automation Systems, leveraging digital twins (virtual objects) and intelligent IoT devices to enhance building efficiency, particularly in terms of energy usage, and to foster innovation.

Odin Solutions (OdinS) is an SME accredited as an innovative ICT company by MINECO, ANCES and EU Digital SME Alliance. Odin has a strong background in the R&D fields of IoT/5G, Edge/Cloud Computing, Cybersecurity, and AI Data analytics, proven in more than 40 research & innovation projects. OdinS designs, develops, and sells secure and interoperable products that are able to connect infrastructures and mobile platforms for Smart Cities, Precision Agriculture, Maritime, eHealth, and Industry 5.0.

The Needs

The primary need identified was to reduce the energy consumption of HVAC systems, which typically account for up to 40% of a building's total energy usage. Current HVAC systems operate on predefined schedules, failing to adapt to actual room occupancy and usage patterns, leading to significant energy waste. There was a clear need for a solution to dynamically adjust HVAC operations based on real-time occupancy data to ensure energy is not wasted on unoccupied spaces. Furthermore, the existing HVAC systems could not integrate seamlessly with modern IoT devices and advanced energy management systems. This lack of interoperability made it difficult to implement smart, energy-efficient solutions across different types of buildings with varying systems.

In addition to reducing energy consumption, there was a need to enhance indoor air quality and maintain comfortable indoor environments without compromising energy efficiency. This required HVAC systems that could intelligently balance temperature control, ventilation, and air quality based on real-time data and changing conditions within the building. Another critical need was ensuring the new systems and technologies incorporated robust cybersecurity measures to protect sensitive data and control access. As buildings become smarter and more connected, safeguarding against potential cyber threats and unauthorised access to systems and data becomes increasingly important. Lastly, these solutions needed to be cost-effective and easily customisable to cater to different building sizes, types, and usage patterns. Solutions that were too expensive or difficult to implement would not be practical for widespread adoption, particularly in older buildings or those with limited budgets for upgrades.

The solution

NEPHELE proposed a comprehensive solution involving intelligent, customisable, and interoperable IoT devices to make HVAC systems more energy-efficient (see Figure 1). The solution starts with real-time occupancy prediction, utilising advanced IoT devices with built-in intelligence (see Figure 2). These devices use AI algorithms like TinyML to process sensor data and accurately predict room usage. With this real-time data, the system can dynamically adjust the operation of HVAC systems, ensuring energy is not wasted on unoccupied spaces. The IoT devices feature adaptable algorithms, allowing them to customise their operation based on the specific environment of each room or building section. This adaptability ensures optimised energy management tailored to the unique usage patterns of different spaces. Furthermore, the solution emphasises interoperability, ensuring these IoT devices can seamlessly integrate with existing building management systems. This integration allows for a cohesive and efficient energy management system across the entire building. Finally, robust cybersecurity measures are embedded within the solution to protect data and control access, leveraging technologies like Verifiable Credentials, Decentralized Identifiers, and Distributed Ledger Technologies to ensure secure and reliable operation.

Funded by the European Union

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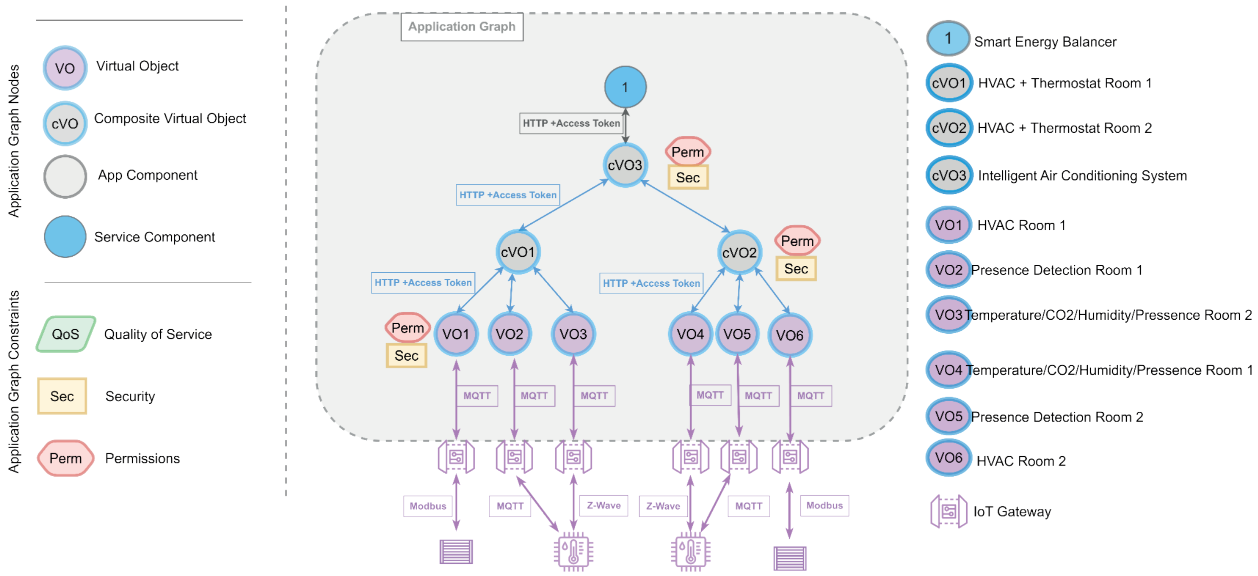

Figure 1. Application graph for the energy management use case

Figure 2. IoT Infrastructure (Temperature, humidity, and CO2 IoT sensor; SIEMENS TargetV device; Raspberry Pi 4 Model B IoT Gateways)

The Challenge

The major challenge was the inability of current HVAC systems to accurately predict room occupancy. Existing systems typically operate on fixed schedules, which do not account for variations in room usage throughout the day. This inefficiency results in significant energy waste, as heating, cooling, and ventilation continue even when spaces are unoccupied. Another challenge was the integration of new technologies with existing systems. Ensuring seamless interoperability between new IoT devices and legacy HVAC systems required sophisticated solutions and collaboration with various stakeholders. Additionally, maintaining cybersecurity and data privacy while deploying these advanced IoT solutions was crucial to prevent unauthorised access and protect sensitive information.

The Project Involved

The EU-funded NEPHELE project is a Research and Innovation Action (RIA) funded by the Horizon Europe programme, aiming to create efficient, reliable, and secure orchestration of hyper-distributed applications across the Cloud-to-Edge-to-IoT continuum. The project addresses barriers in openness and interoperability between IoT, cloud, and edge computing, leveraging 5G and distributed AI technologies for automation and decentralised intelligence. NEPHELE introduces an IoT and edge computing software stack that enables the virtualisation of IoT devices at the edge, supporting openness and interoperability in a device-independent manner. Additionally, it features a synergetic meta-orchestration framework that coordinates cloud and edge computing platforms through high-level scheduling and system supervision. These innovations will be demonstrated and validated across various industries, including disaster management, port logistics, energy management in smart buildings, and remote healthcare. The project will also conduct two open calls and aims to foster a broad open-source community to support its outcomes.

The Service Provider

The distributed application that is developed in this use case is going to be deployed and managed by the developed synergetic meta-orchestration (SMO) solution in the NEPHELE project. The NEPHELE SMO supports the intent-driven deployment and lifecycle management of distributed applications over programmable multi-cluster compute and network infrastructure that spans across the computing continuum.

Impact

The implementation of NEPHELE's solution led to significant energy savings in smart buildings. The solution reduced unnecessary energy consumption by enabling HVAC systems to adjust dynamically based on real-time occupancy data, directly contributing to lower operational costs for building owners and managers. The intelligent IoT devices facilitated more efficient use of renewable energy sources, aligning with global sustainability goals and reducing buildings' carbon footprint.

Additionally, the improved energy management contributed to better indoor air quality and more consistent indoor temperatures, enhancing occupant comfort and well-being. The Smart Energy Balancer, a key component of the solution,

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optimised the operation of HVAC systems by managing the timing and intensity of heating, cooling, and ventilation processes. This ensured energy efficiency and prolonged the lifespan of HVAC equipment by preventing overuse and wear.

Moreover, the integration of advanced cybersecurity measures protected sensitive data and maintained the integrity of building management systems, fostering trust among users and stakeholders. The success of NEPHELE's solution demonstrated the potential for intelligent, IoT-based energy management systems to transform building operations, setting a benchmark for future developments in the field.

Future Developments

Future developments will focus on enhancing the intelligence of IoT devices, further integrating AI techniques like TinyML, and expanding the use of Distributed Ledger Technology for secure access control. These advancements will continue to drive energy efficiency and sustainability in smart buildings.

Recommendations for policymaking

Policymakers should consider the following actions to encourage the adoption of intelligent energy management solutions in buildings:

- **Provide Incentives:** Offer financial incentives for integrating IoT and AI technologies in HVAC systems to encourage widespread adoption. These incentives could include tax breaks, grants, and low-interest loans for building owners and managers who implement these advanced technologies. By reducing the upfront cost barrier, more stakeholders will be motivated to invest in energy-efficient solutions, accelerating the transition towards smarter, greener buildings.
- **Promote Standardisation:** Support standardisation entities like ETSI and W3C to ensure interoperability and security in IoT and AI technologies. Establishing common standards will facilitate the seamless integration of diverse devices and systems, making it easier for building managers to adopt new technologies without compatibility issues. Standardisation also enhances security by providing uniform protocols for data protection and access control, thereby fostering a trustworthy environment for deploying smart building solutions.
- **Support Research and Development:** Fund research and development initiatives focused on enhancing the capabilities of IoT devices and AI techniques in energy management. Government and private sector collaboration can drive innovation in this field, leading to the development of more advanced, efficient, and cost-effective solutions. By supporting R&D, policymakers can help create cutting-edge technologies that address the specific challenges of energy management in buildings, ultimately contributing to global sustainability efforts.

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