Smart Home Lighting

System Description

Abstract
This document provides the System of Systems Description (SoSD document) for the **Smart Home Lighting** local cloud.

Contents

1 Overview

This document describes the **Smart Home Lighting** system of systems (SoS), which provides a robust and decentralized solution for controlling home lighting through a local cloud infrastructure.

The system comprises a movement sensor and a smart lamp, integrated with key services including service discovery, service orchestration, authentication, and authorization to ensure seamless operation. This local cloud setup ensures privacy, low latency, and reliability, as all services are maintained and executed within the local network.

The rest of this document is organized as follows. In Section 1.1, we reference major prior art capabilities of the SoS. In Section 1.2, we describe the intended usage of the SoS. In Section 1.3, we describe fundamental properties provided by the SoS. In Section 1.4, we describe delimitations of capabilities of the SoS. In Section 2, we describe the microsystem (abstract level with references to their SysDs) which constitutes the SoS. In Section 3, we describe the security capabilities of the SoS.

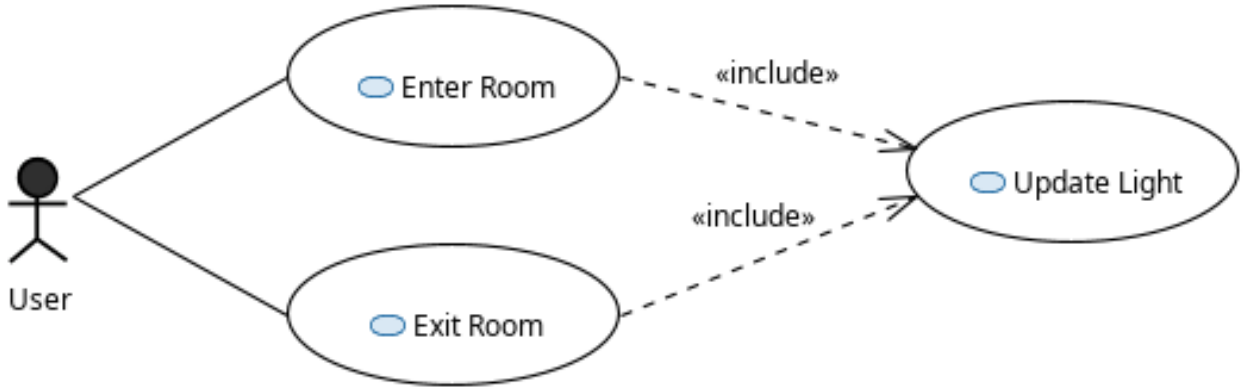

Figure 1: SysML use case diagram. A user can enter a room and the light will be turned on, depending on the movement of the person. A user can also leave a room and if no other person is in the room, the light will be turned off.

1.1 Significant Prior Art

Significant prior art includes LED lighting systems for energy efficiency, AAA battery-powered devices like motion sensors for wireless operation, and communication protocols to enabled local, decentralized control of smart home devices.

1.2 How This SoS Is Meant to Be Used

The Smart Home Lighting system is designed to automatically control lighting based on motion detection. When the motion sensor detects movement, the data is processed by an AI system that analyzes patterns and determines whether to turn the lamp on or off, improving accuracy and avoiding false triggers. The AI system operates within the local cloud, ensuring low latency and privacy.

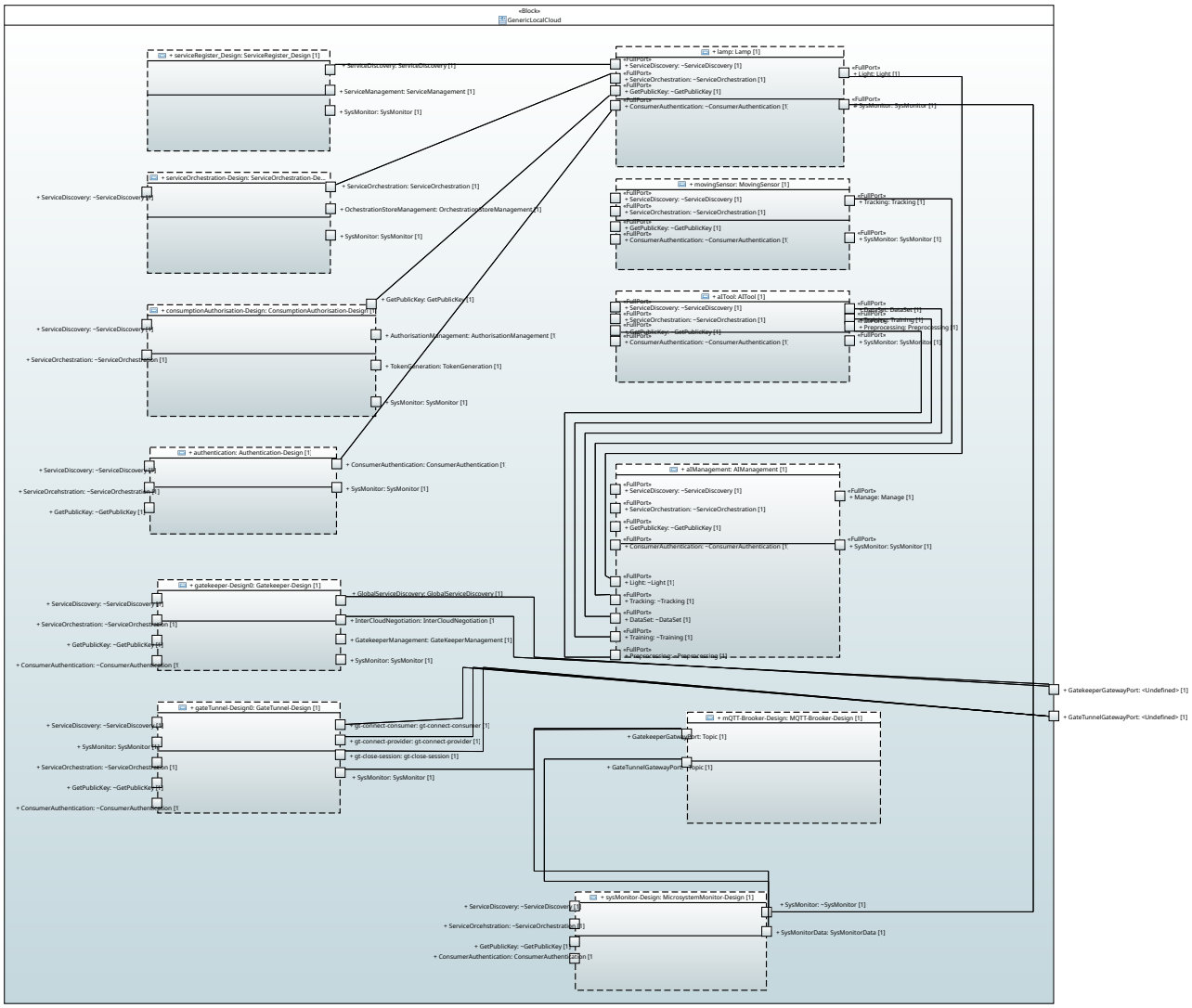

Figure 2: System Definition Block Diagram of the Local Cloud

1.3 SoS functionalities and properties

1.3.1 Functional properties of the SoS

The functional properties of the local cloud in the Smart Home Lighting system include:

- *Service Discovery:* Devices like the lamp, the motion sensor, and the AI system automatically register and discover each other, enabling seamless communication within the local network.
- *Service Orchestration:* Coordinates the interaction between devices, ensuring the AI processes motion sensor data efficiently and triggers the appropriate action (turning the lamp on or off).
- *Data Processing:* Handles the real-time analysis of motion sensor data using AI to make intelligent decisions about lighting control.
- *Authentication and Authorization:* Ensures secure access, only allowing authorized devices and users to interact with the system, enhancing security and preventing unauthorized control.
- *Local Execution:* All services and data processing occur within the local network, providing low latency, high reliability, and enhanced privacy as no external cloud is needed.
- *Resource Management:* Efficiently manages power and communication between devices, especially battery-operated ones like the motion sensor or the lamp, optimizing energy usage.

1.3.2 Configuration of SoS properties

The system configuration allows for adjusting the AI model used for processing motion sensor data. Users can fine-tune the AI model, optimizing parameters such as sensitivity or detection patterns, and then apply it directly to the motion sensor. Once the model is deployed, the sensor can process data locally, reducing the need to send large volumes of raw data to the local cloud. This improves efficiency, reduces network load, and extends the battery life of the sensor while maintaining intelligent control over the lighting system.

1.3.3 Non functional properties

- The Smart Home Lighting system ensures security through authentication and authorization protocols, allowing only trusted devices and users.
- Safety is maintained by ensuring reliable operation of the lighting system, minimizing failure risks
- Energy consumption is optimized through the use of efficient LED lighting and battery-powered sensors.
- Latency is kept low as all data processing occurs within the local cloud, ensuring real-time responsiveness.
- Power-saving properties are enhanced by the AI model, which reduces data transmission from the sensor, extending battery life and minimizing overall power usage.

1.3.4 Stateful or stateless

- The model state of the Ai model is preserved
- The lamp state is preserved, so whether light is on or off.

1.4 Important Delimitations

The Smart Home Lighting system has important delimitations regarding its functionality. It cannot handle dimming, color changes, or animations, limiting its control to basic on/off operations. Additionally, the lamps are stationary and cannot be moved, which constrains lighting placement. The motion sensors must also remain in fixed positions; if relocated, the AI model must be retrained to ensure accurate detection and response. These constraints highlight the system's focus on straightforward lighting control rather than more complex or dynamic lighting features.

2 Services

2.1 Produced service

2.1.1 service Light of Lamp

The purpose of this service is to provide a possibility to determine, whether light should be emitted or not. The service is offered for the application system. See Light SD document for more details.

2.1.2 service SysMonitor of Lamp

The purpose of this service is to generate monitoring data for a consumer with the current status of the lamp. The service is offered for the application system. See MicrosystemMonitor SD document for more details.

2.1.3 service Tracking of MovingSensor

The purpose of this service is to query movement data of the sensor for a room. The service is offered for the application system. See Light SD document for more details.

2.1.4 service SysMonitor of MovingSensor

The purpose of this service is to generate monitoring data for a consumer with the current status of the MovingSensor. The service is offered for the application system. See MicrosystemMonitor SD document for more details.

The local cloud also provides some services for the interaction with other local clouds. Those include a GlobalServiceDiscovery, a InterCloudNegtiation, a GateTunnelConnectProvider, and a GateTunnelCloseSession. The corresponding SysD and SD documents can be found in the Gatekeeper-Design document or the GateTunnel-Design document.

2.2 Consumed services

The system does not need to consume services to run. For the interaction with other local clouds it consumes the GateTunnelConnectConsumer service, which can be found in the GateTunnel-Design document.

3 Security

The security of Eclipse Arrowhead — and therefore the security of the Lamp — is relying on X.509 certificate trust chains. The Arrowhead trust chain consists of three levels:

- Master certificate: `arrowhead.eu`
- Cloud certificate: `my-smarthome.smarthome.arrowhead.eu`
- Client certificate: `my-lamp.my-smarthome.smarthome.arrowhead.eu`

For Arrowhead certificate profile, see: `https://github.com/eclipse-arrowhead/documentation`
The system does not contain configuration for Arrowhead unsecure/ secure mode.

4 References

5 Revision History

5.1 Amendments

No.	Date	Version	Subject of Amendments	Author
1	2024-10-12	4.6.2		Max Lütkemeyer

5.2 Quality Assurance

No.	Date	Version	Approved by
1	2024-10-12	4.6.2	