SmartPool: An Automated CPS for Real-Time Water Quality Management

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About Me

André Correia da Costa

Master's student in Informatics and Computer Engineering at FEUP.

I'm a researcher at INESC TEC, where my work is focused on the development of **Asset Administration Shells** (AAS) and the integration of communication protocols in industrial environments.

Agenda

1. Context & Motivation
2. Problem Statement
3. Research Goals & Contributions
4. SmartPool Architecture
5. Proof-of-Concept
6. Limitations
7. Vision for the Future

Context & Motivation

Problem Statement

Manual Checks

Traditional pool maintenance relies on manual water parameter checks.

Time-Consuming

Scheduling manual checks can take days.

Financial Inefficiency

Manual maintenance can lead to financial inefficiencies.

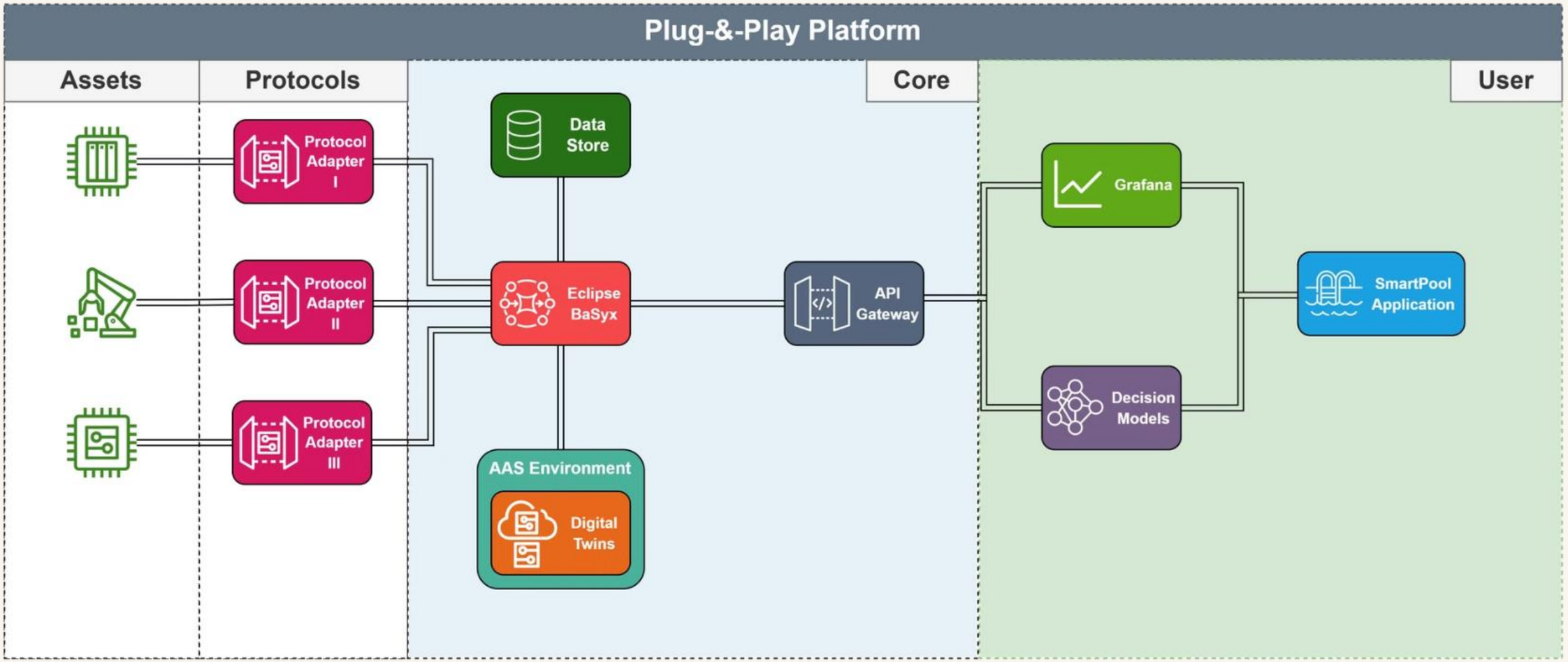
Research Goals & Contributions

Autonomous Pool Maintenance Solution

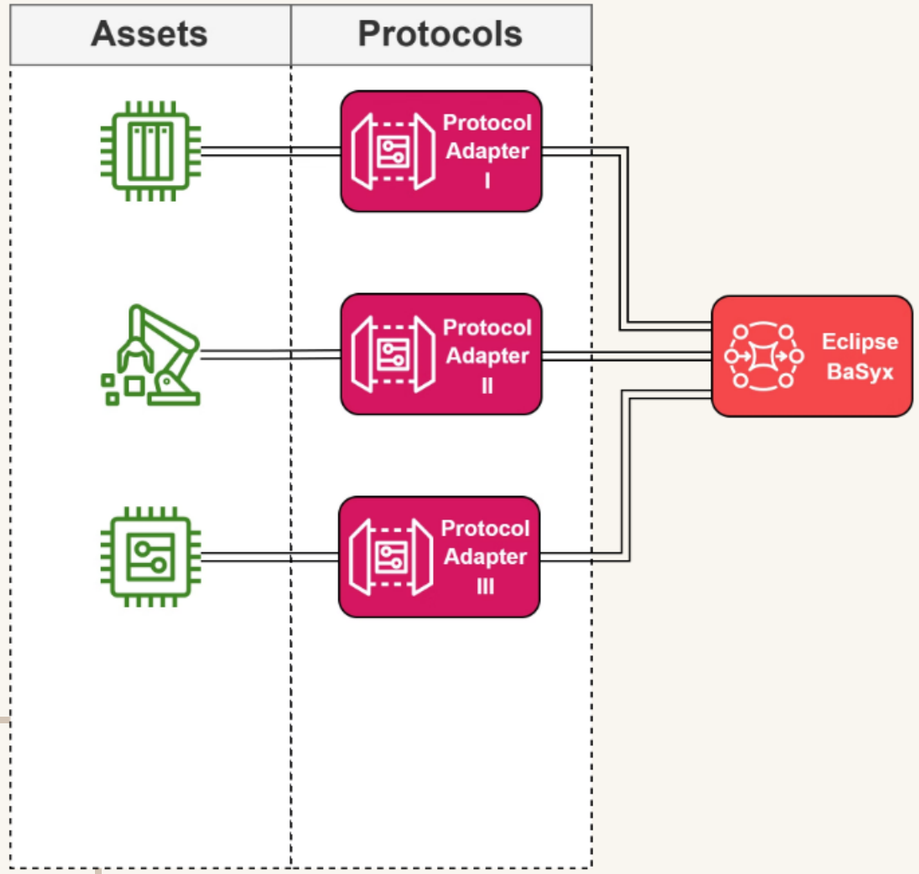
Improve Time and Financial Efficiency

- **Remove** the need for **manual & local** pool parameters checks.
- **Autonomous calibration** of parameters.
- **Digital adjustments** of optimal Pool parameters.

SmartPool Architecture



Data Collection



Control through Digital Replica

Middleware → Eclipse BaSyx

MQTT

OPCUA

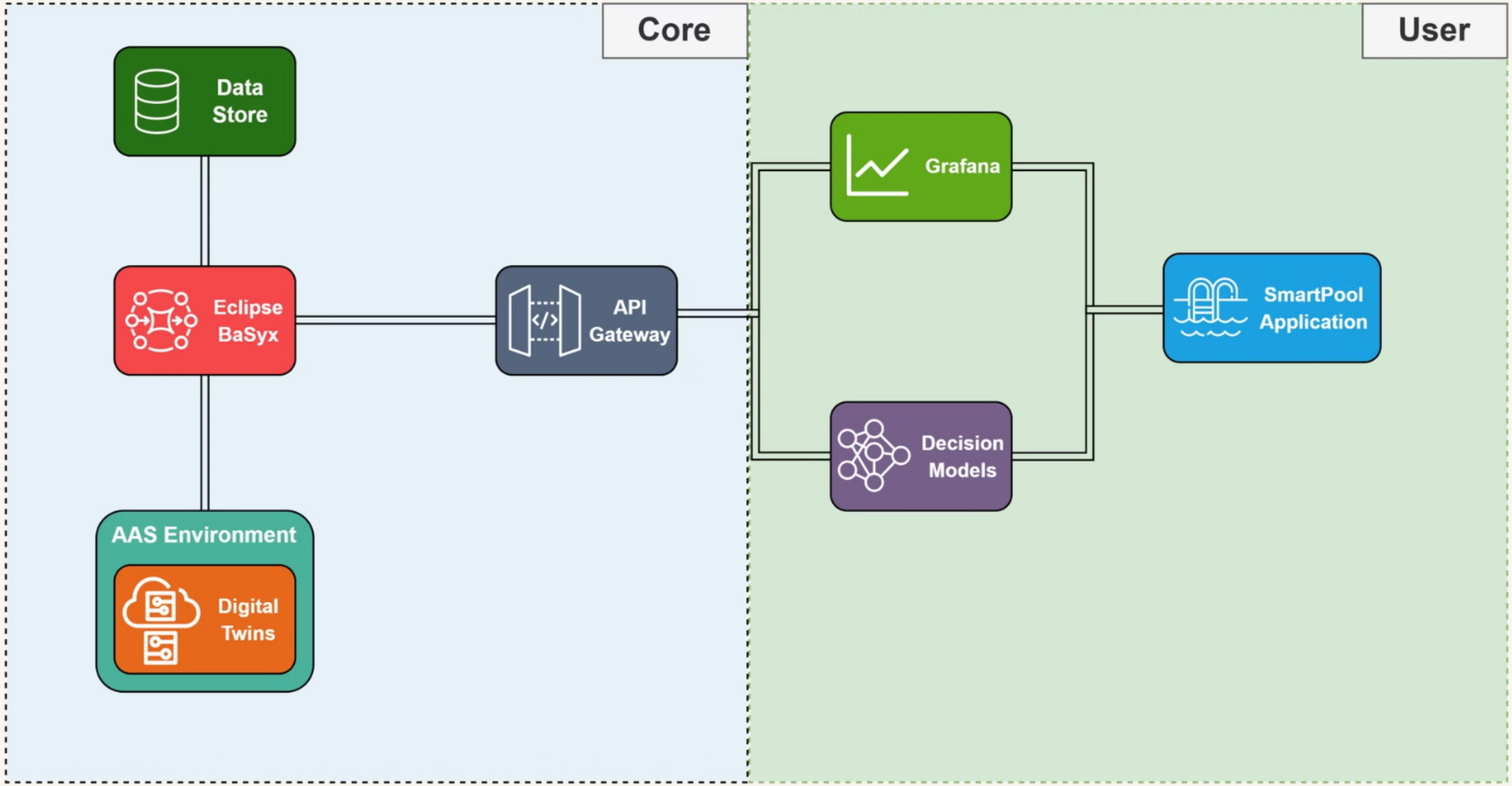
HTTP

KAFKA

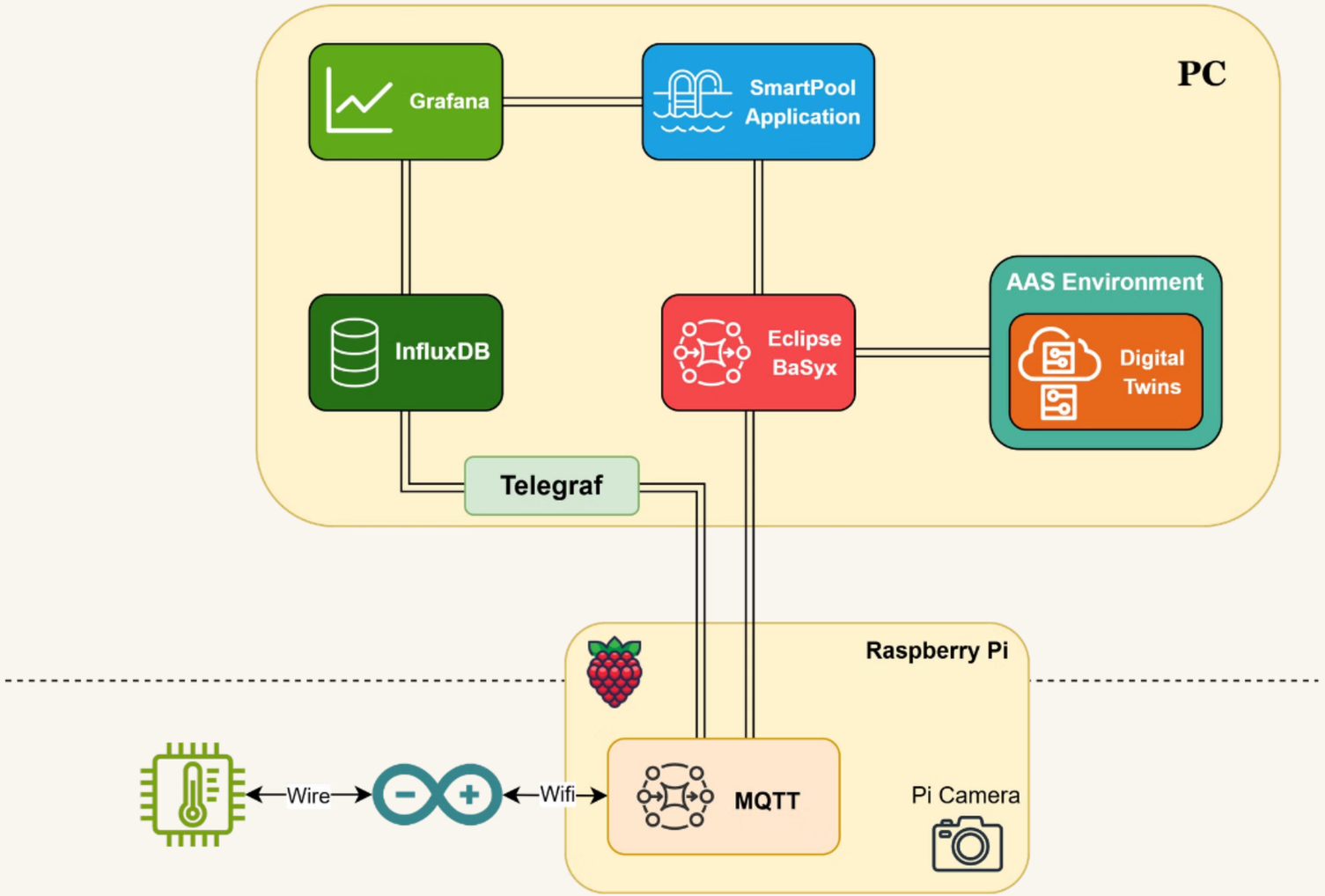
PLC4X

Asset Administration Shell

Represenation of Digital Twins
in a standardized semantic.


Core
User
Data Store
Eclipse BaSyx
API Gateway
Grafana
SmartPool Application
Decision Models
AAS Environment
Digital Twins

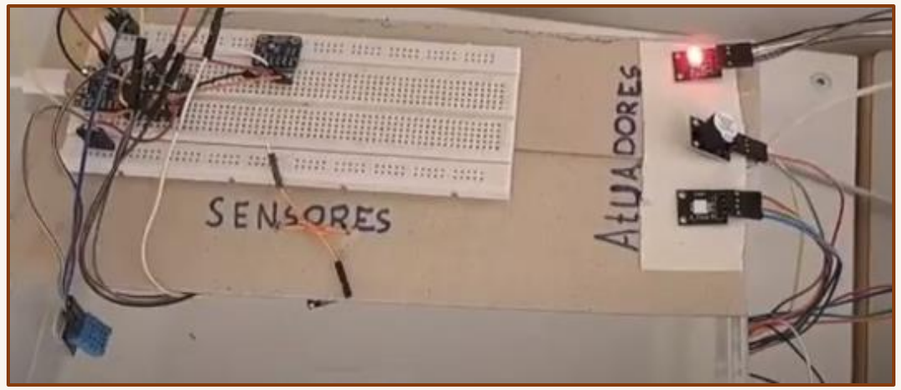
Proof of Concept



Proof of Concept: Hardware Components

Sensors

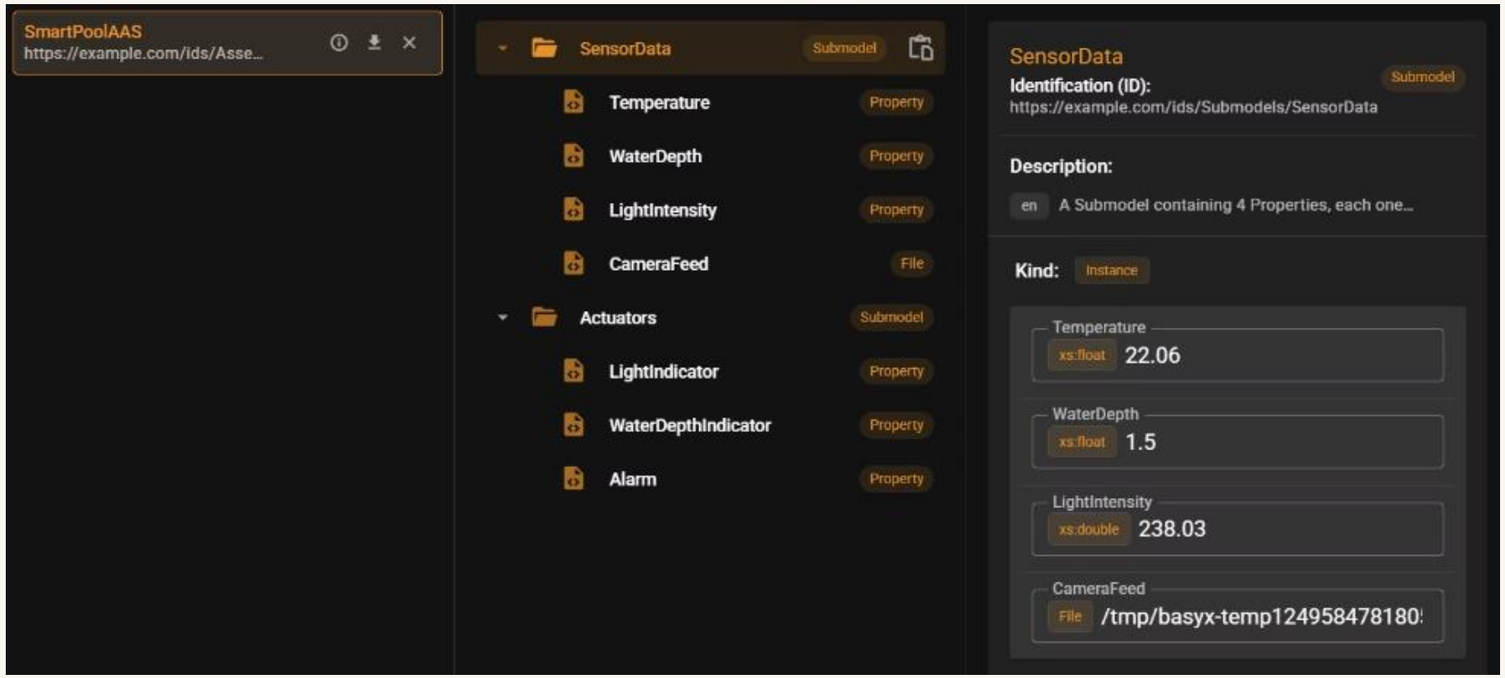
- Temperature sensor
- Ultrasonic sensor (to measure Water Depth)
- Light Intensity sensor
- Camera

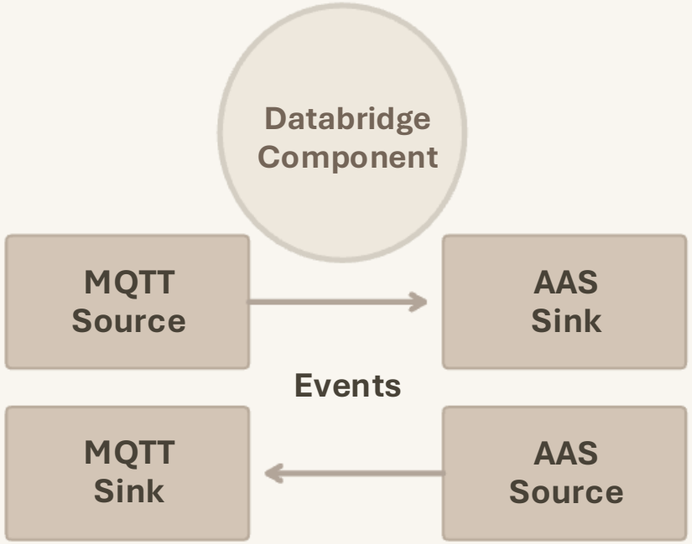


Actuators

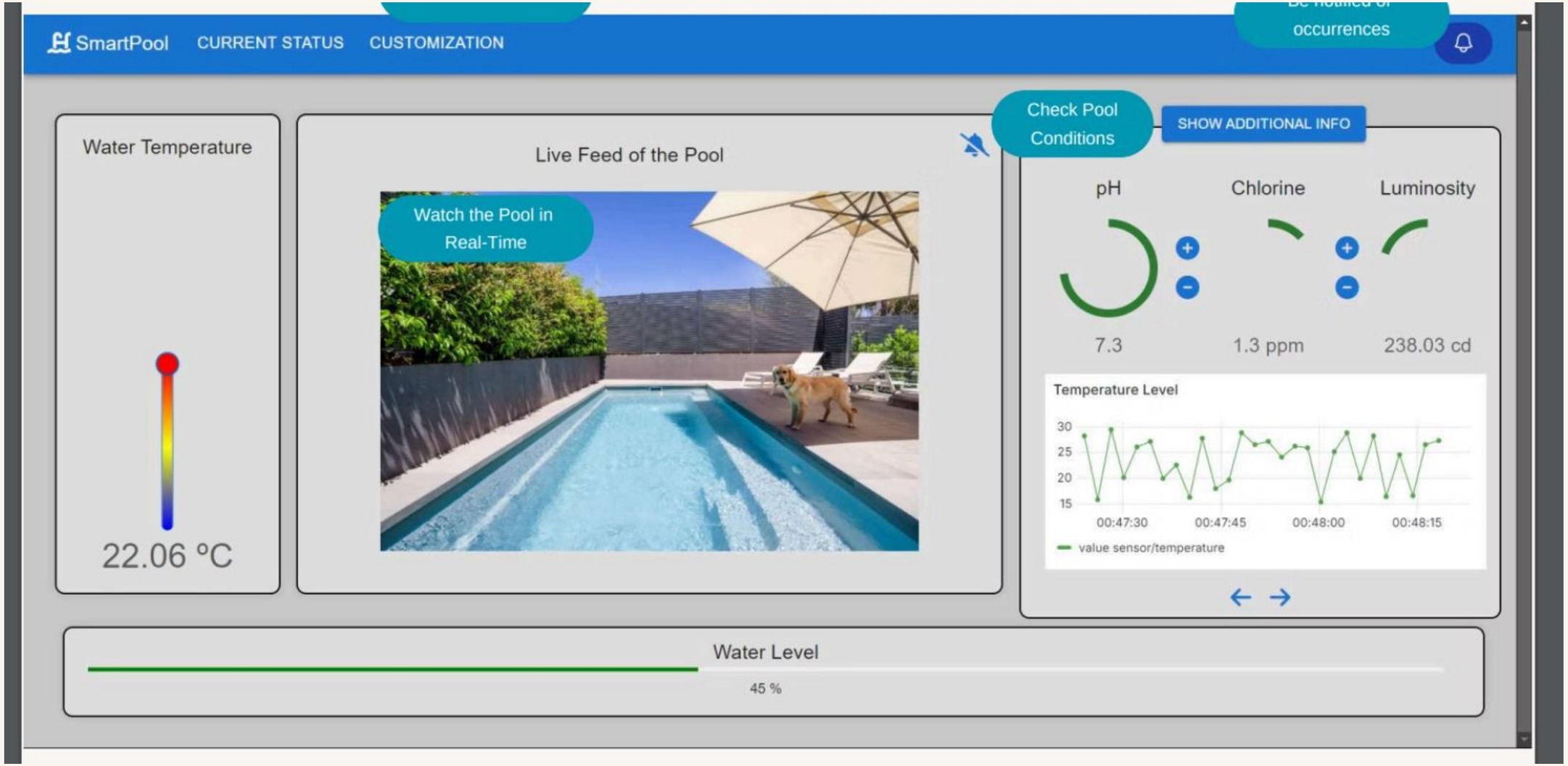
- Light Indicator (LED)
- Water Depth Indicator (LED)
- Alarm

Proof of Concept: Middleware





Proof of Concept: SmartPool Web Application



Beyond the Basics SmartPool Enhancements

Camera Integration

A camera **connected to the Raspberry Pi**, with **machine learning algorithms** to identify people, dogs, or cats.

External Device Interaction

Allows **interaction of external devices** like personal computers with Raspberry Pi, if within the same network.

Limitations

High Initial Setup Cost

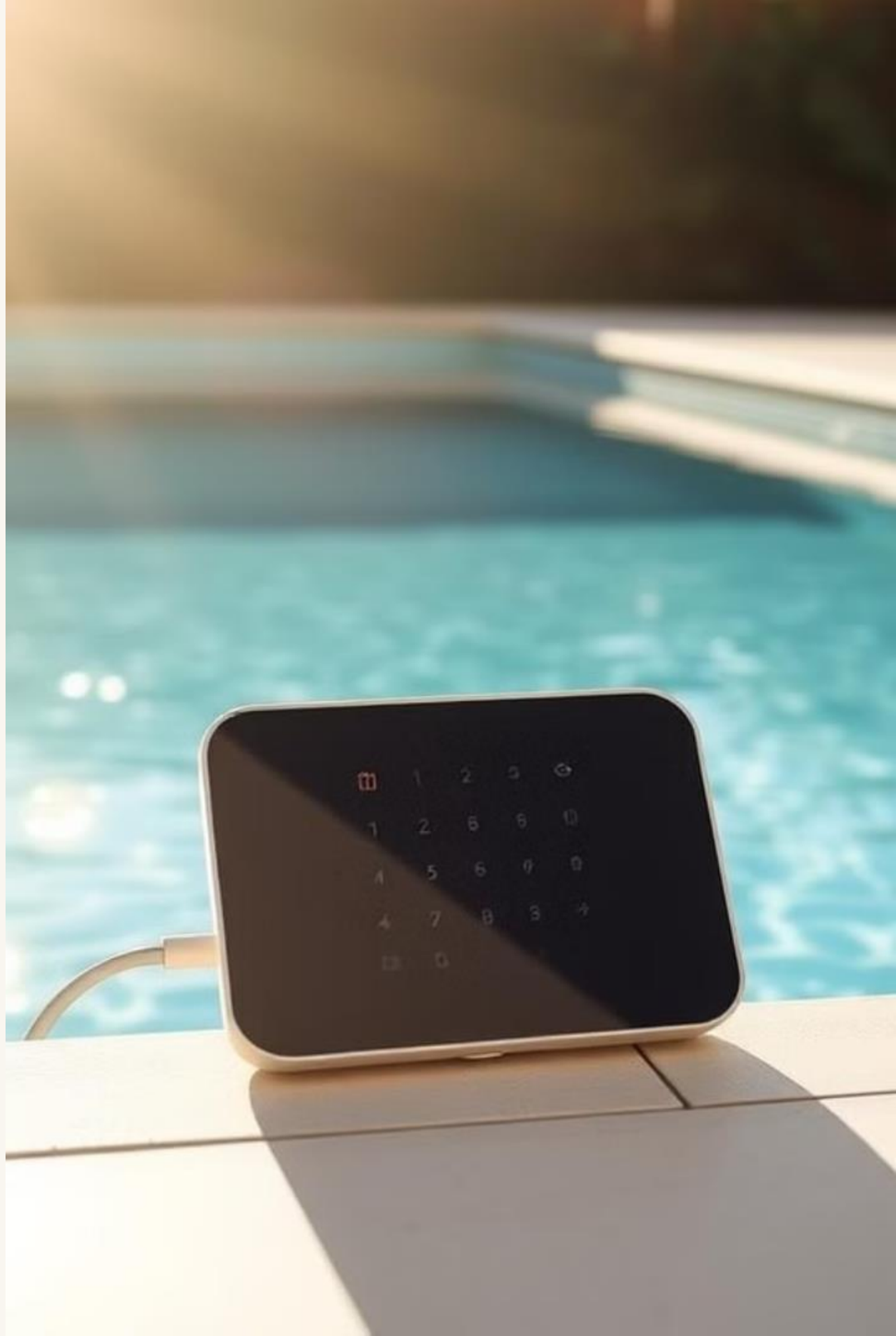
Initial Investment in Hardware.

Reliability on WiFi Connection

To send data over the Internet.

Hardware Maintenance

Maintenance is still required on hardware devices.



Vision for the Future

Feasibility in Real-World Environments

Evaluate system performance in **varied climates** and **unpredictable** conditions.

Expansion to Different Pool Types & Industry Sectors

Adapt SmartPool Solution for **public** and **saltwater** pools, as well as potential industrial and **aquaculture** applications.

Integration with AI for Predictive Maintenance & Optimization

Further studies on machine learning models for **predictive maintenance** and **automated anomaly detection**.

Conclusion

Automated CPS for Water Quality

SmartPool system automates real-time water quality management.

Feasibility Demonstrated

Proof of concept utilizes sensors, actuators, and middleware.

Future Expansion

Potential for diverse pool types and AI integration.

Towards a **Smarter**, **More Sustainable Pool Management** System!

Thank You!