

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

Team

- André Ávila
- André Costa (presenter)
- André Soares
- Daniel Rodrigues
- Eduardo Ramos
- João Alves
- João Matos
- Lourenço Gonçalves
- Luís Cabral
- Marco André



Presenter: André C. Costa @ FEUP

Contact: up201905916@up.pt

Supervisors: Prof. Rui Pinto; Prof. Gil Gonçalves



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



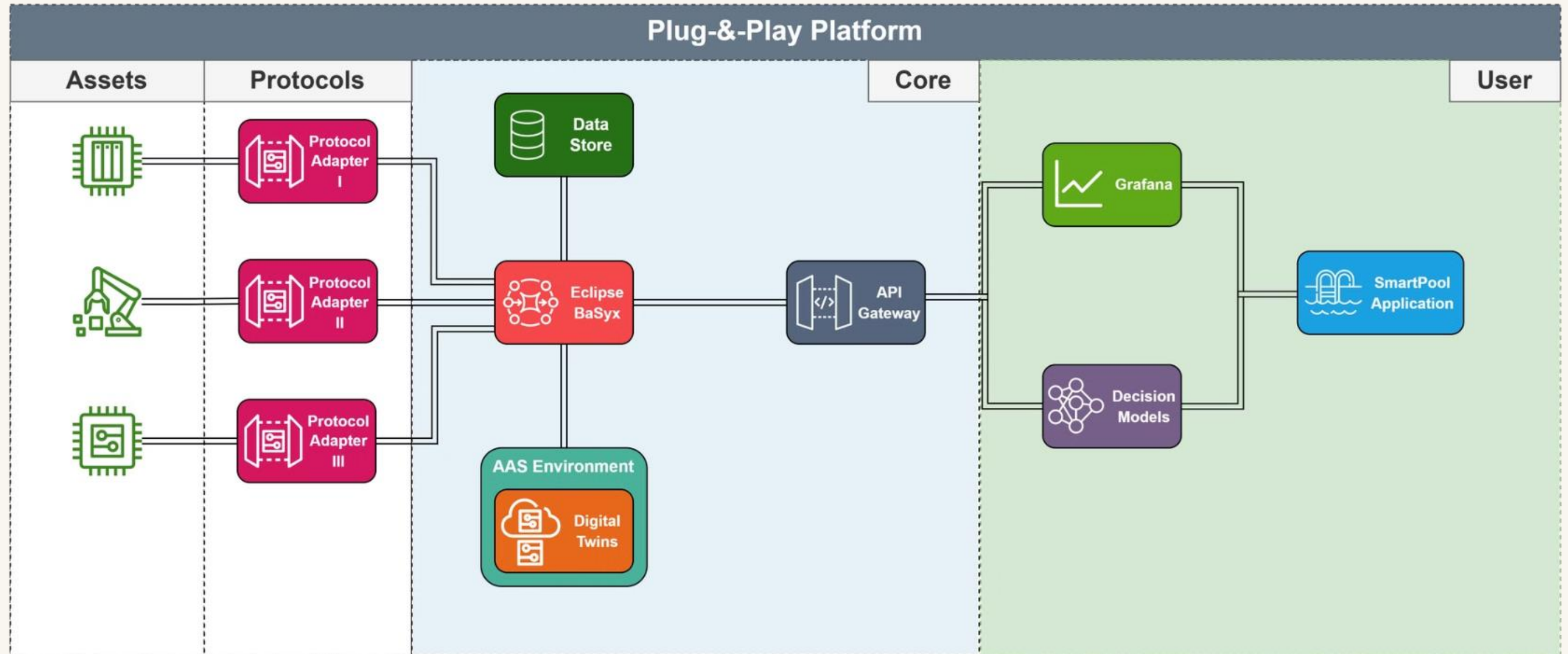
Autonomous Pool Maintenance Solution



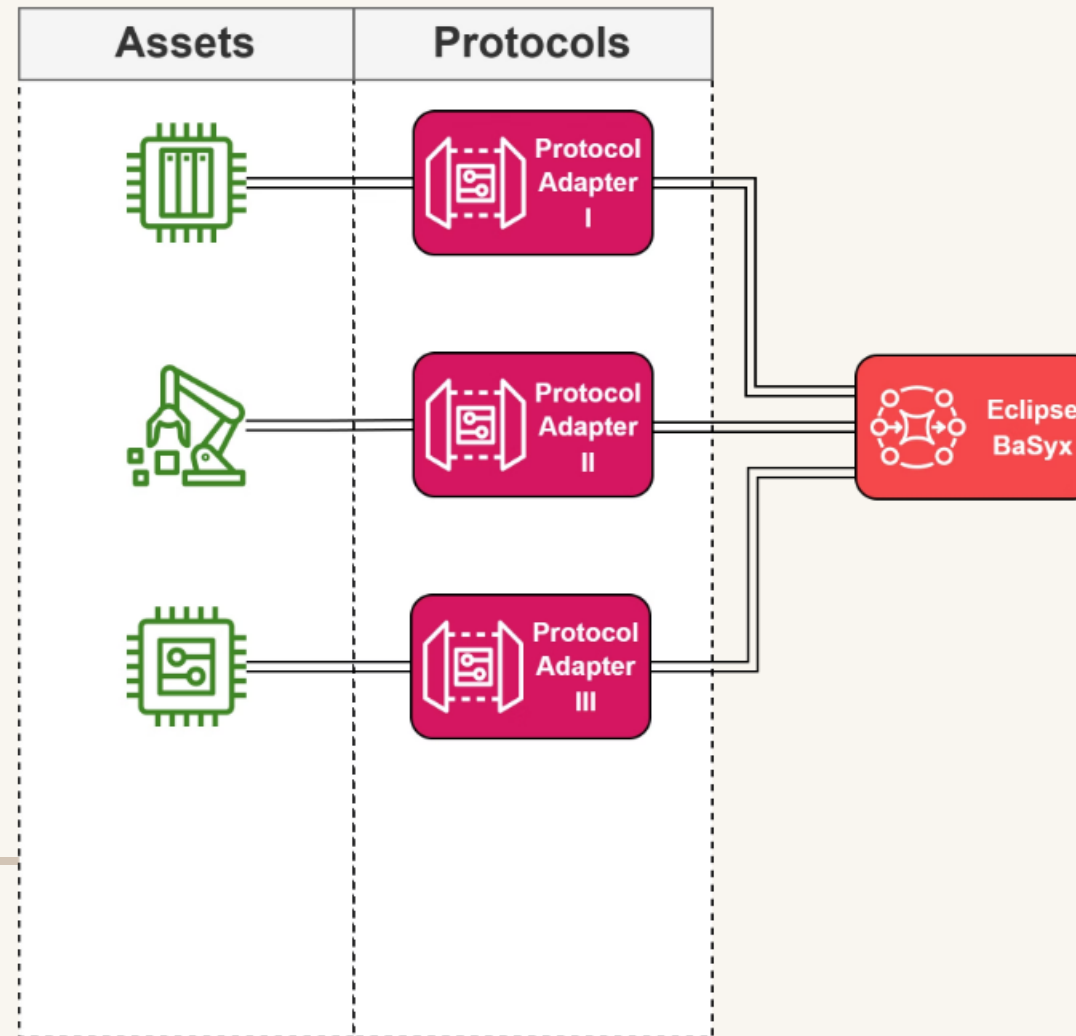
Improve Time and Financial Efficiency

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

SmartPool Architecture

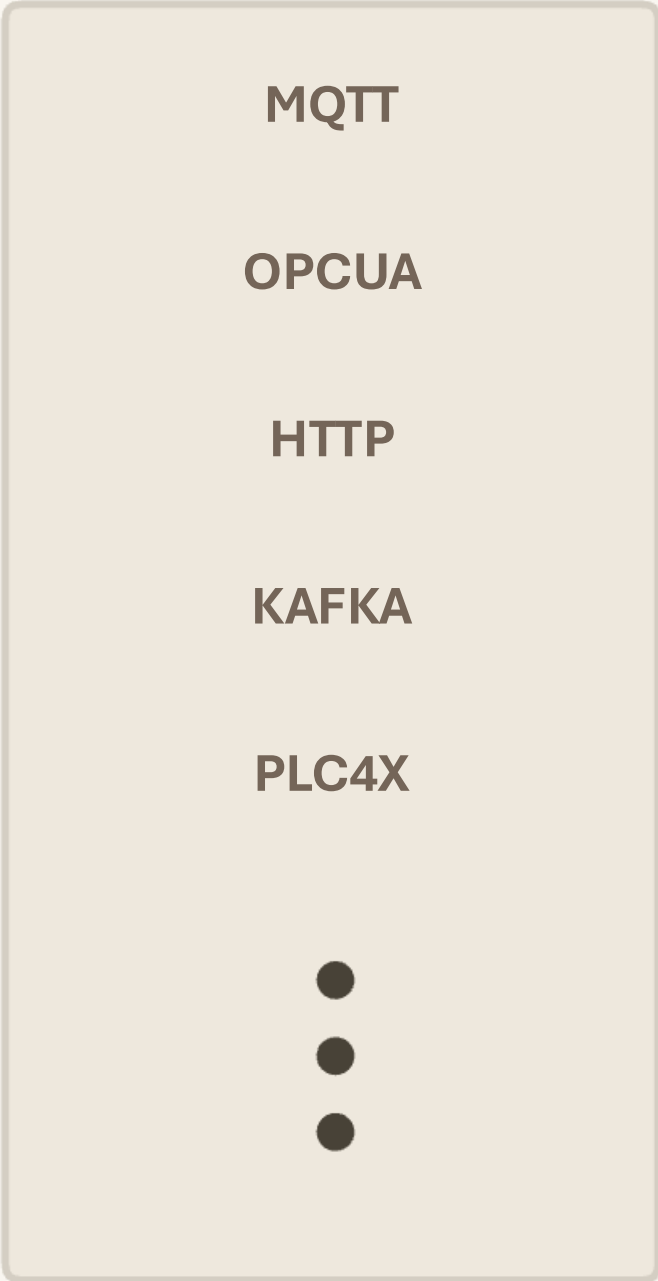


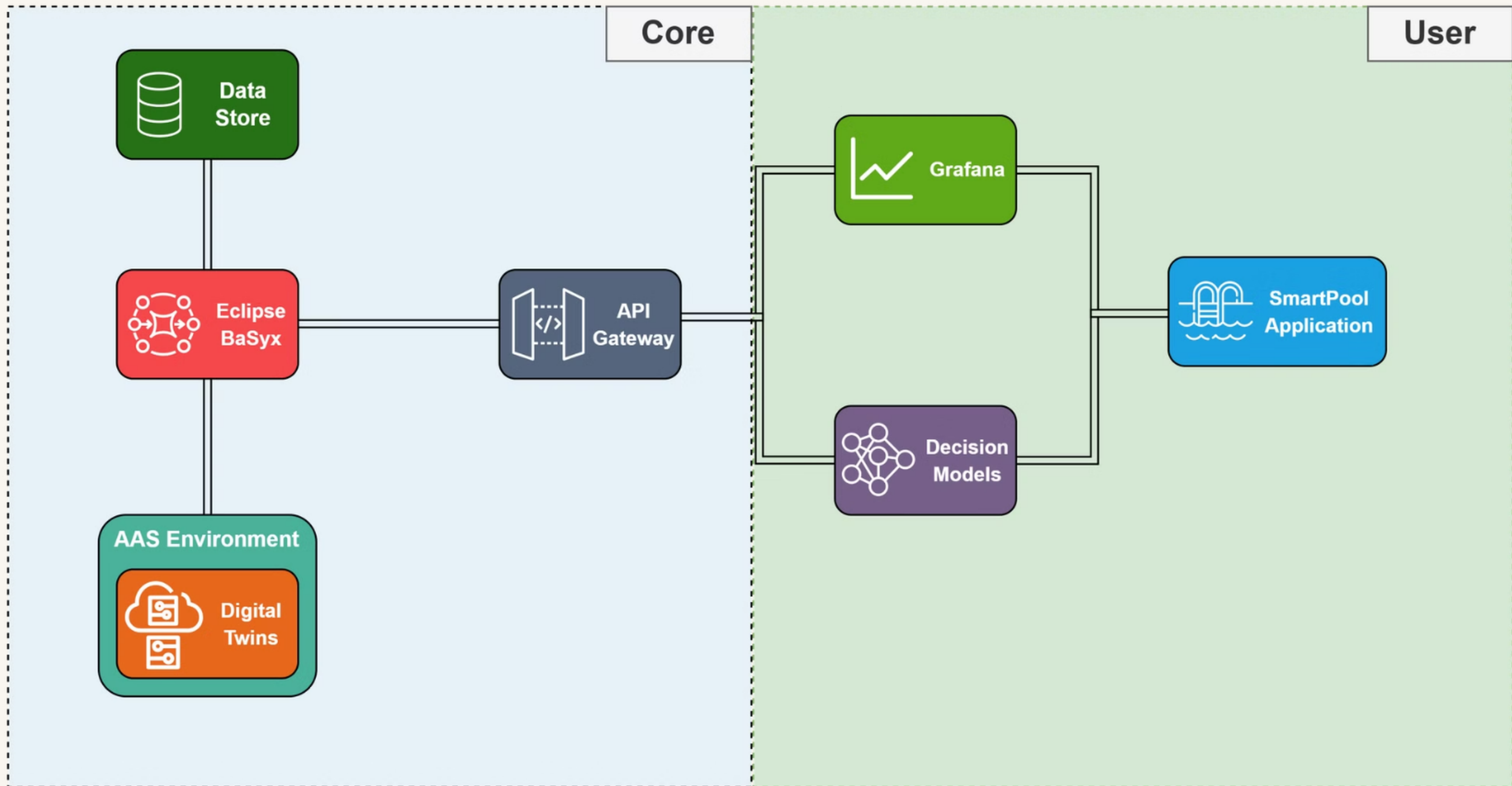
Data Collection



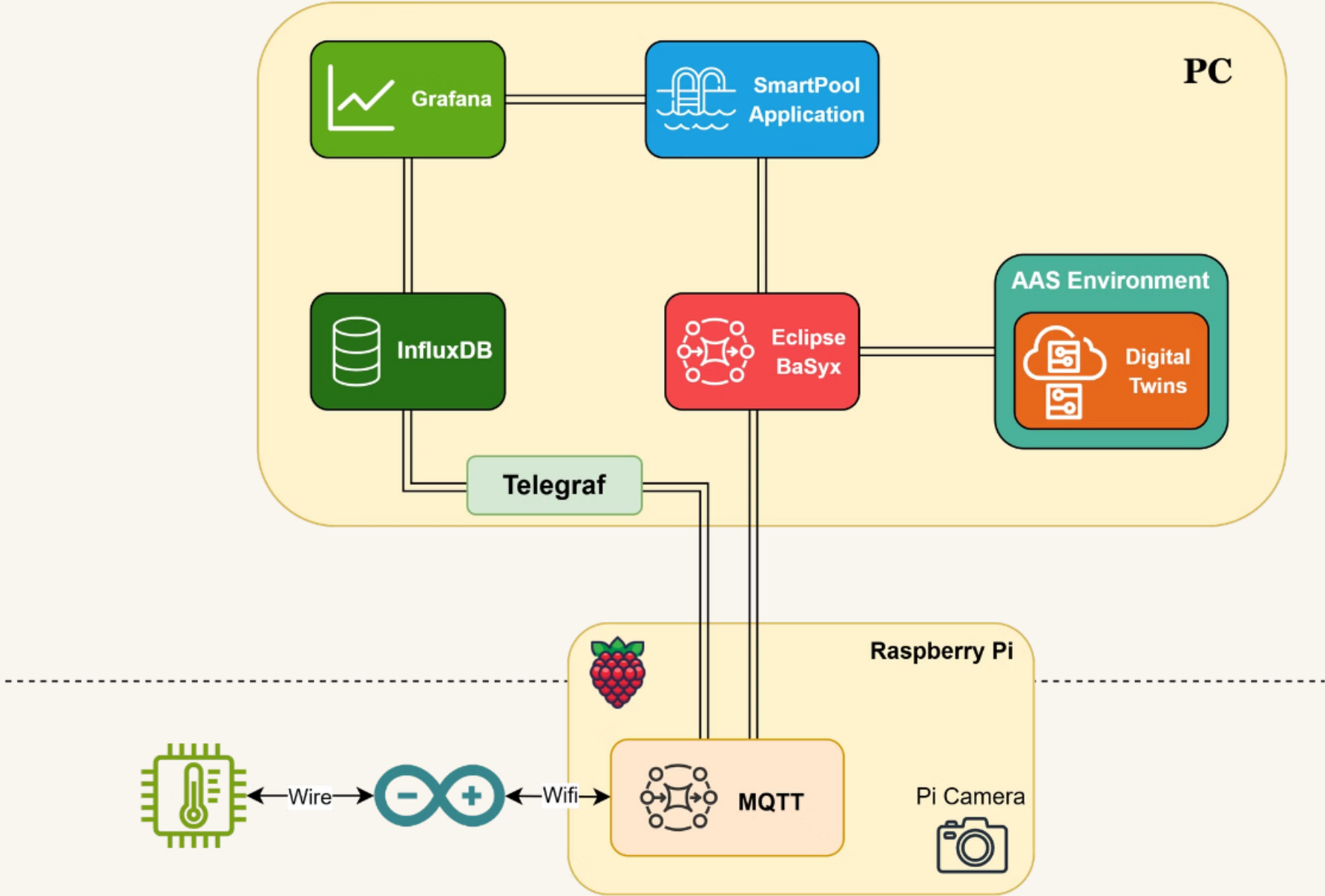
Control through
Digital Replica

Middleware → Eclipse BaSyx





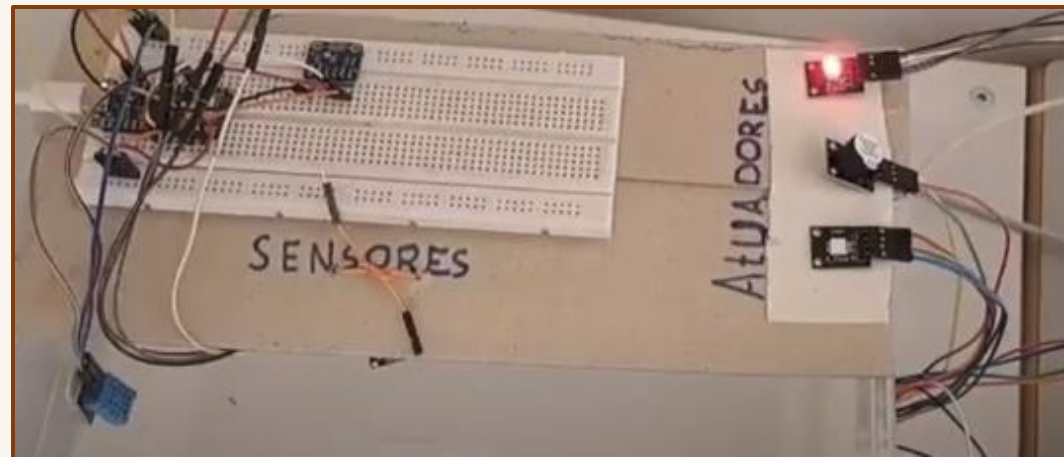
Proof of Concept



Proof of Concept: Hardware Components

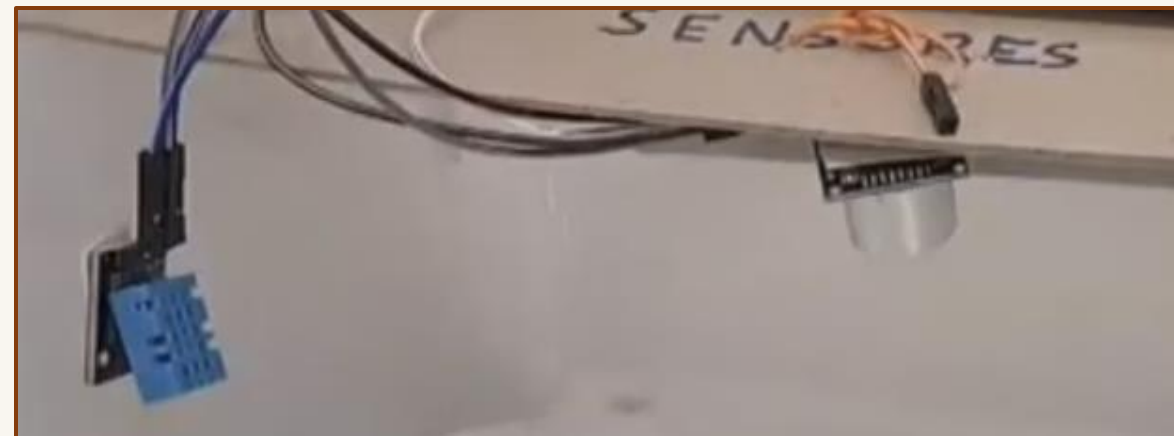
Sensors

- 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

The screenshot displays the SmartPoolAAS web interface. The top left shows the application name and URL. The main area is divided into a left sidebar with a tree view and a right pane showing details for the selected 'SensorData' submodel.

SmartPoolAAS
https://example.com/ids/Asse...

SensorData (Submodel)

- Temperature (Property)
- WaterDepth (Property)
- LightIntensity (Property)
- CameraFeed (File)

Actuators (Submodel)

- LightIndicator (Property)
- WaterDepthIndicator (Property)
- Alarm (Property)

SensorData (Submodel)

Identification (ID): https://example.com/ids/Submodels/SensorData

Description: en A Submodel containing 4 Properties, each one...

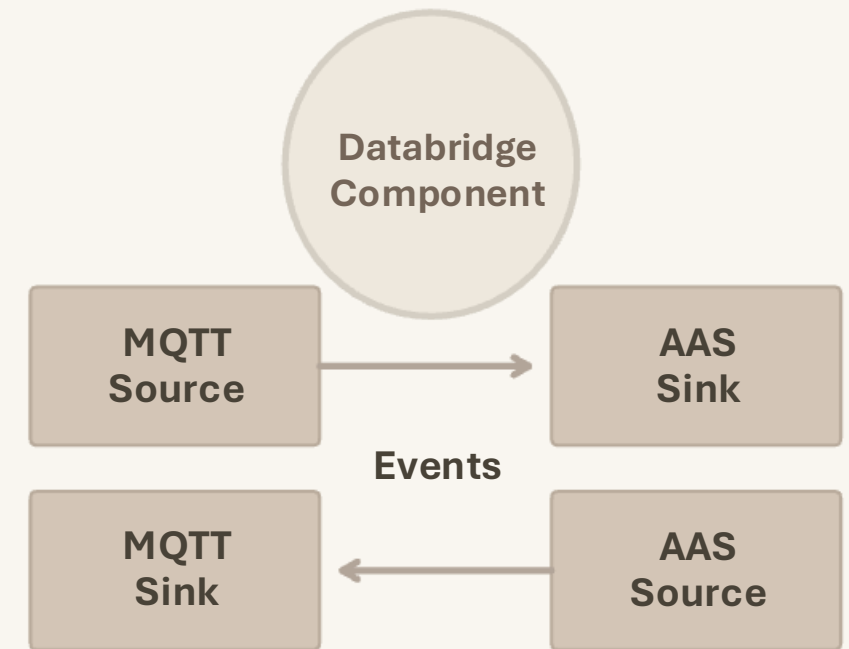
Kind: Instance

Temperature: xs:float 22.06

WaterDepth: xs:float 1.5

LightIntensity: xs:double 238.03

CameraFeed: File /tmp/basyx-temp124958478180!



Proof of Concept: SmartPool Web Application

The screenshot displays the SmartPool web application interface. At the top, there is a navigation bar with the SmartPool logo, 'CURRENT STATUS', and 'CUSTOMIZATION' links. A notification bell icon is visible on the right. The main content area is divided into several sections:

- Water Temperature:** A vertical thermometer-style gauge showing a reading of 22.06 °C.
- Live Feed of the Pool:** A video feed showing a swimming pool with a dog on the deck. A button labeled 'Watch the Pool in Real-Time' is overlaid on the video.
- Check Pool Conditions:** A section with three circular gauges for pH (7.3), Chlorine (1.3 ppm), and Luminosity (238.03 cd). Each gauge has '+' and '-' buttons for adjustment. A 'SHOW ADDITIONAL INFO' button is also present.
- Temperature Level:** A line graph showing temperature fluctuations over time, with a legend indicating 'value sensor/temperature'.
- Water Level:** A horizontal progress bar at the bottom showing the water level is at 45%.

Beyond the Basics SmartPool Enhancements



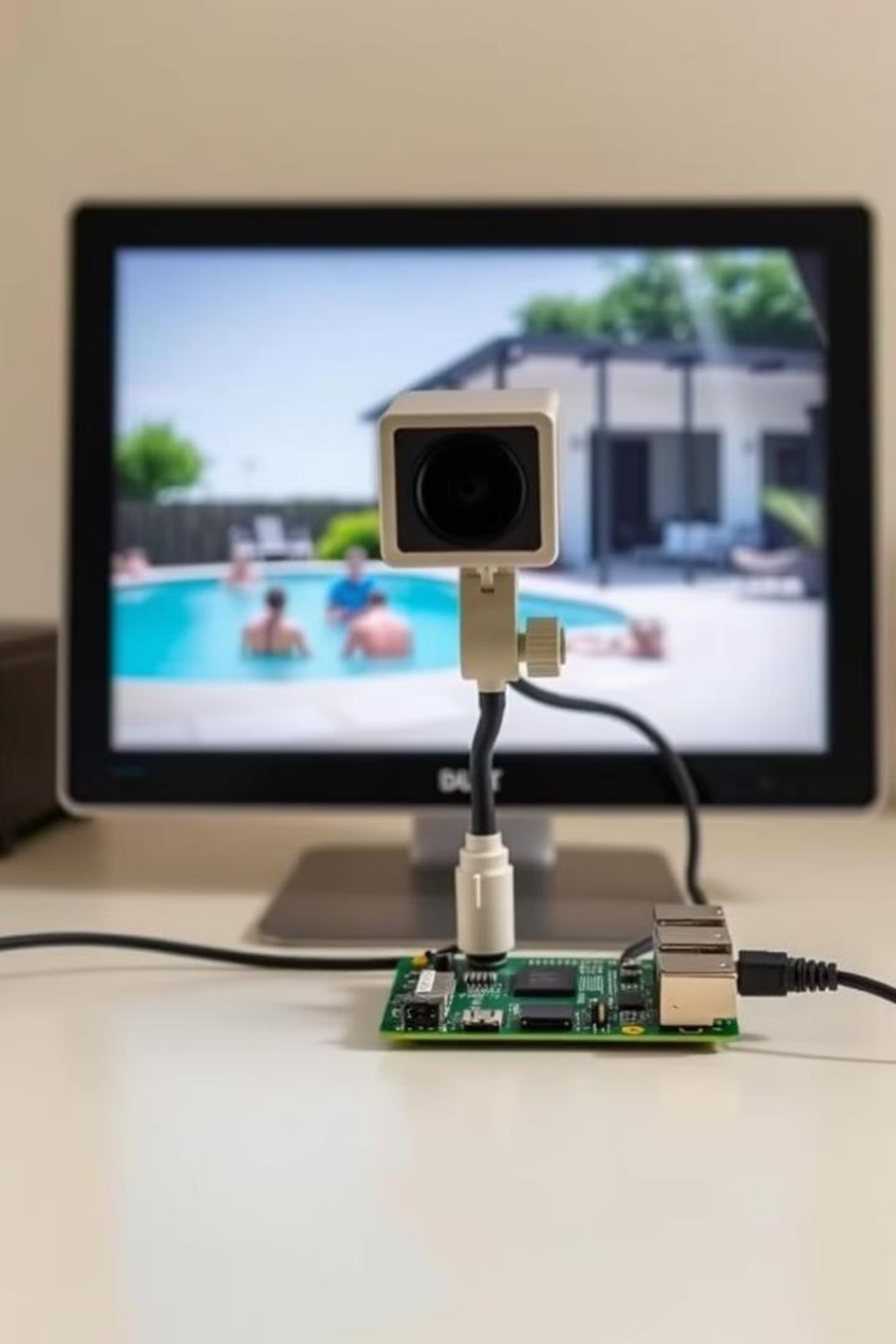
Camera Integration

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.



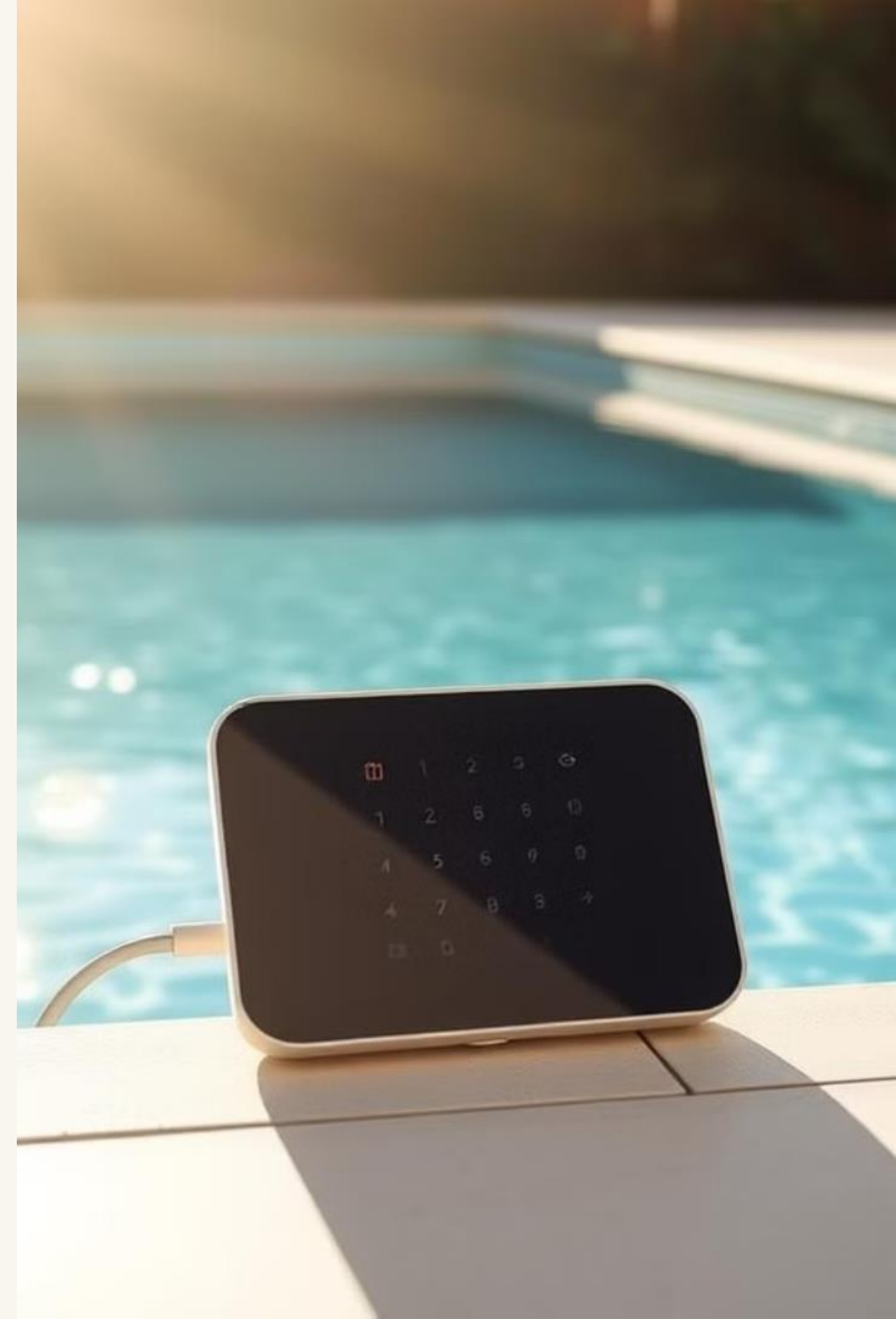
Reliability on WiFi Connection

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!

