STEL IOT

ALESSIA CORNI
MATTEO GOMBIA
MARIANNA SOLMI

a.y. 2024-2025

ONE OF THE MOST FUNDAMENTAL NEEDS FOR ANYONE, WHETHER AT WORK, SCHOOL, OR TRAVELING, IS FINDING THE NEAREST RESTROOM.

In public spaces, finding a clean, available, and well-maintained restroom is often difficult, leading to long queues, poor hygiene, and wasted time.

OVERVIEW

01 What is Stel-IoT?

02 Advantages

03 Agents

04 Overall structure

05 Components

06 FSM

07 Remote control

08 AI

09 Prototype

01

WHAT IS STEL-IOT

A smart solution to monitor the toilets of a business in a centralized way.

A technology designed to detect problems remotely, swiftly notify the staff, and facilitate quick resolution.

A system that utilizes sensors and user feedback, and displays all relevant information on dedicated outputs.

02

ADVANTAGES

Why is Stel-IoT perfect for you?

01

COST REDUCTION

Efficient cleaning and quick repairs significantly reduce time and costs.

02

EFFICIENCY & SUSTAINABILITY

Optimizing resource usage can reduce water and electricity waste while improving efficiency.

03

BETTER QUALITY OF SERVICE

QUALITY OF SERVICE

Usage of AI tools to efficiently predict when the bathroom will need assistence.

Fast repair response

Quick fixes to minimize downtime and ensure continuous service.

Fast cleaning action

Rapid cleaning processes to maintain hygiene and user satisfaction.

03

WHO IS INTERACTING?

This type of service is useful for the users as much as for the operators

USER

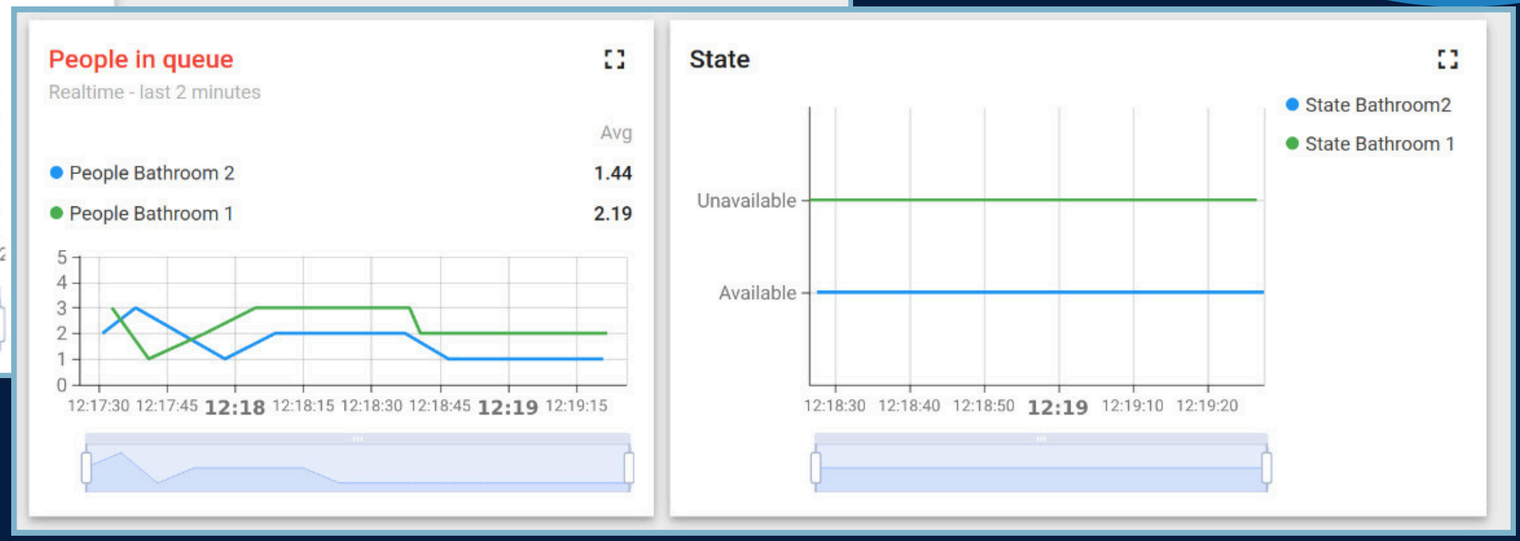
Users can check available restrooms via the mobile app and provide feedback on their experience. The application provides suggestions on which bathroom to use.

OPERATOR

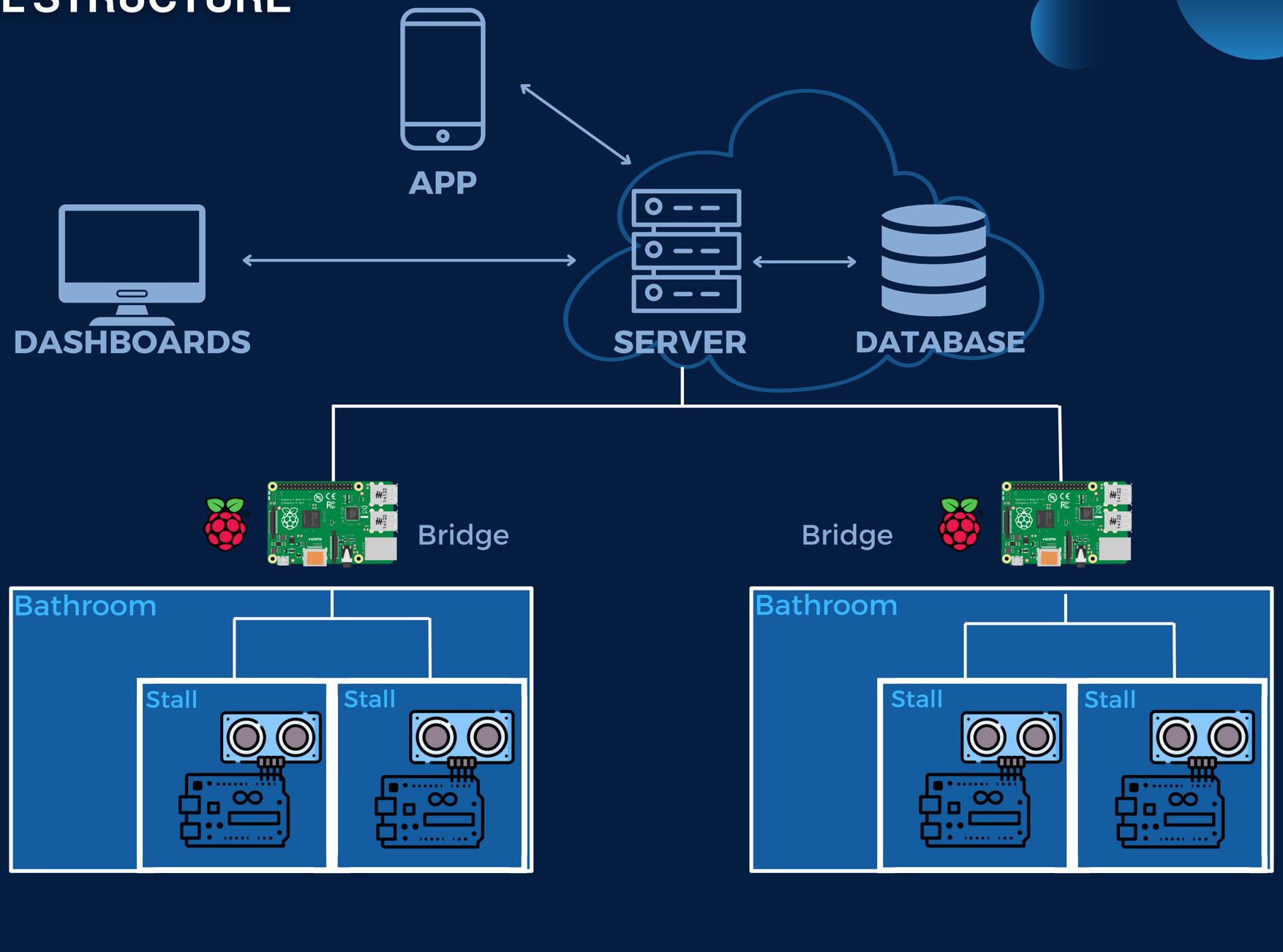
Operators can monitor restroom status, track maintenance and cleaning, and take action when needed.

DASHBOARD

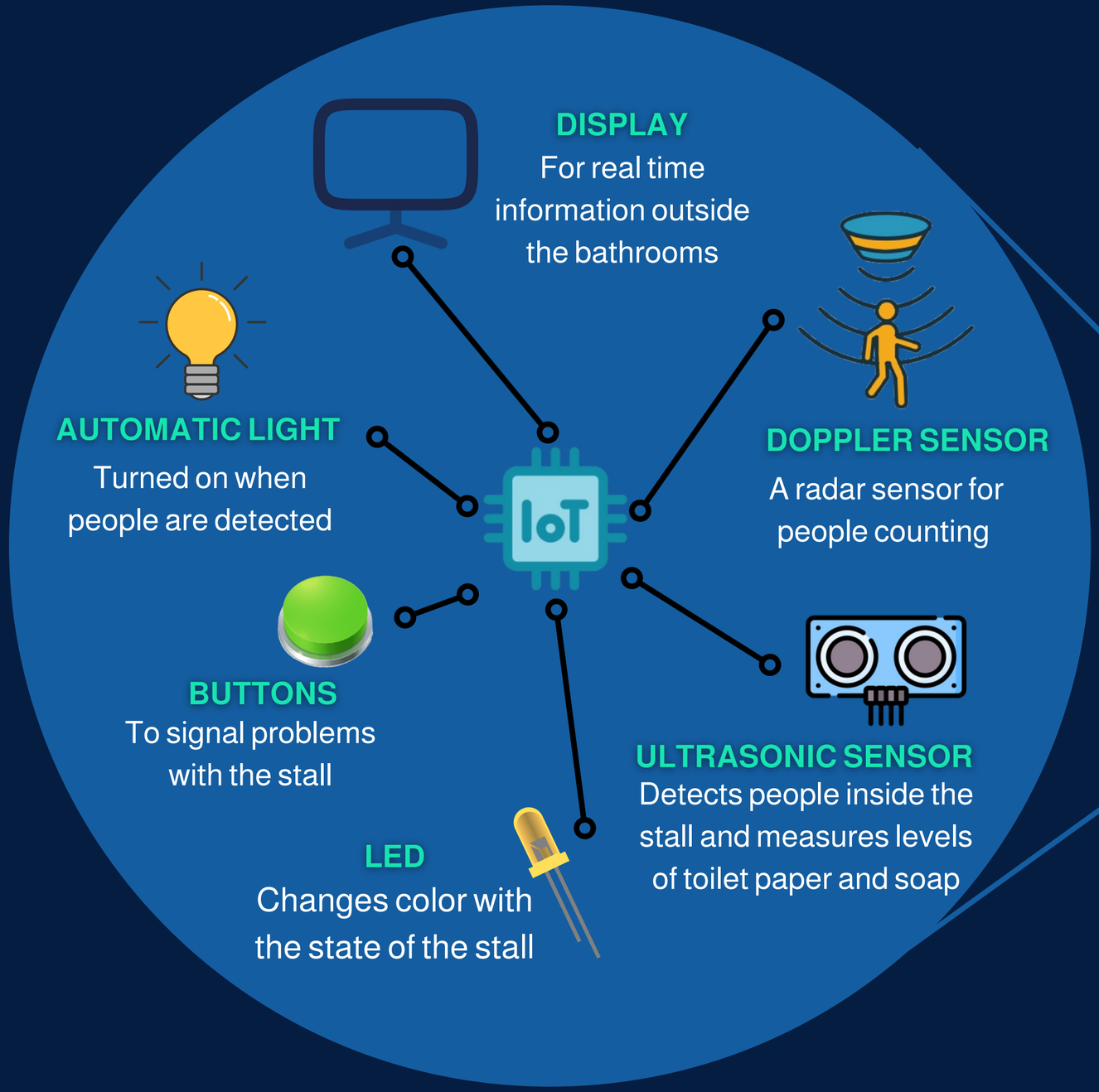

Toilet Paper
Realtime - last 30 seconds
Avg
Toilet Paper 87 %
100
80
60
40
20
0
13:52:20 13:52:26 13:52:32 13:52:38 13:52:44
Toilet Pa... 75 %
Rating
Realtime - last 30 minutes
Avg
Rate 3.62
5
4
3
2
1
0
13:24 13:28 13:32 13:36 13:40 13:44 13:48 13:52
State
History - last 30 seconds
Cleaning
Maintenance
Unusable
Occupied
Free
13:51:44 13:51:48 13:51:52 13:51:56 13:52 13:52:04 13:52:08 13:52:12


People in queue
Realtime - last 2 minutes
Avg
People Bathroom 2 1.44
People Bathroom 1 2.19
5
4
3
2
1
0
12:17:30 12:17:45 12:18 12:18:15 12:18:30 12:18:45 12:19 12:19:15
State
State Bathroom2
State Bathroom 1
Unavailable
Available
12:18:30 12:18:40 12:18:50 12:19 12:19:10 12:19:20

04 OVERALL STRUCTURE



05 COMPONENTS



STALL FINITE STATE MACHINE

POSSIBLE STATES

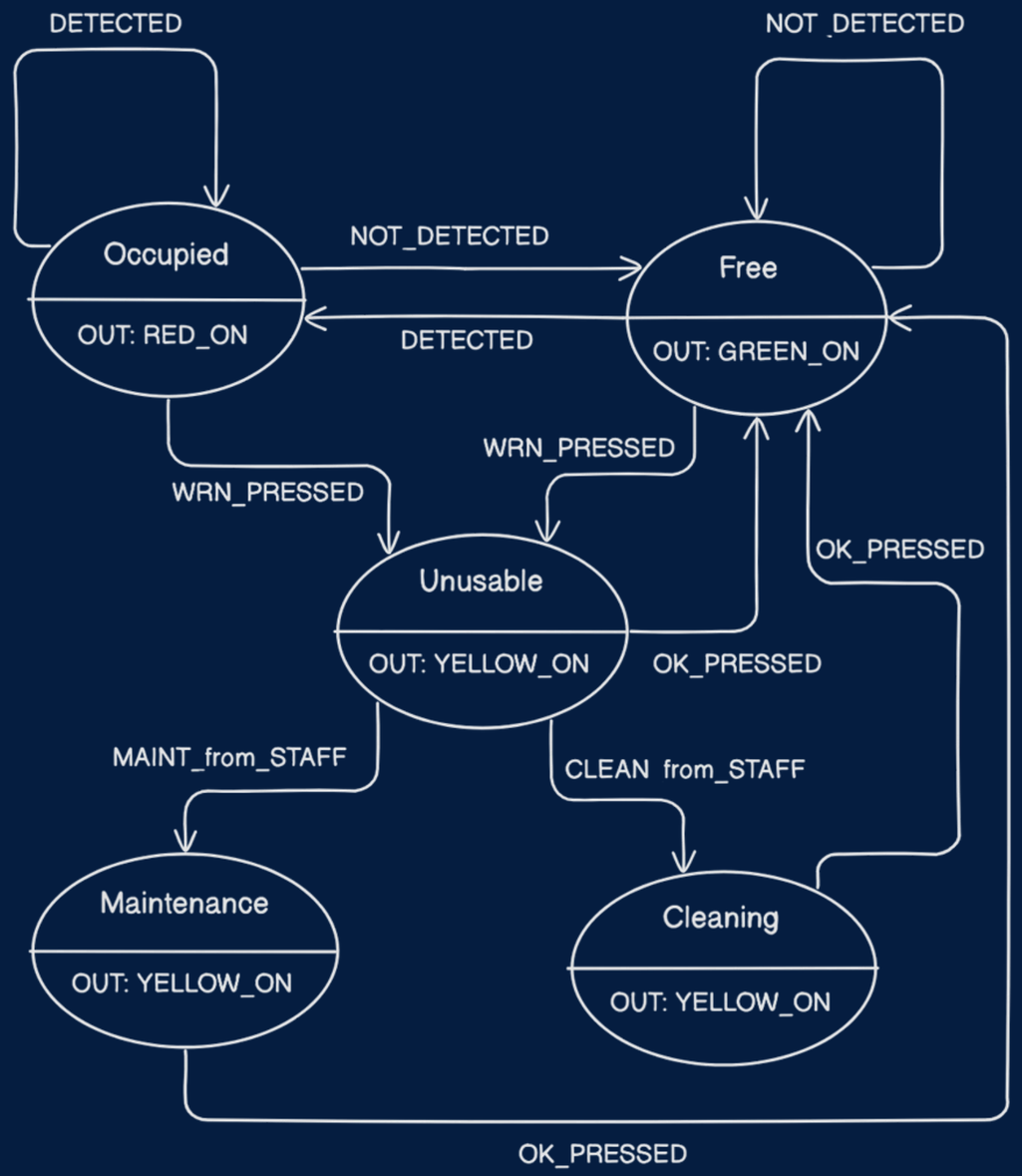
Occupied, Free, Unusable, Cleaning and Maintenance

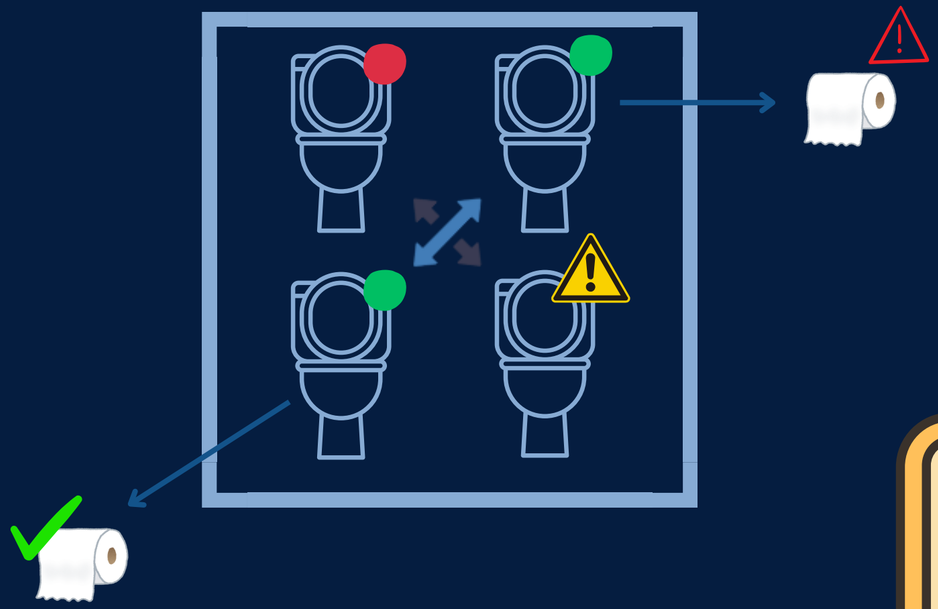
POSSIBLE INPUTS

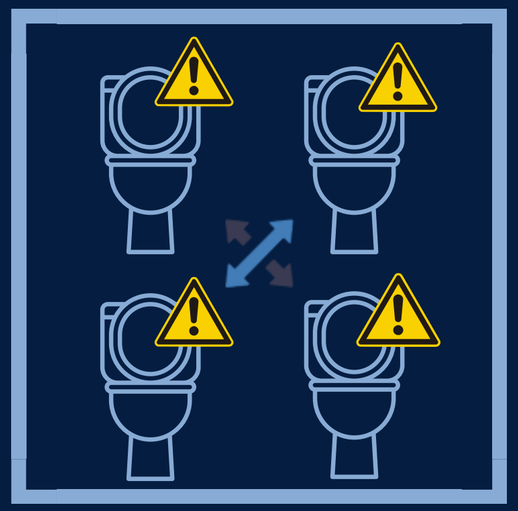
Detected, Not Detected, Warning Button, Ok Button, Maintenance and Cleaning from app

POSSIBLE OUTPUTS

Yellow On, Green On, Red On







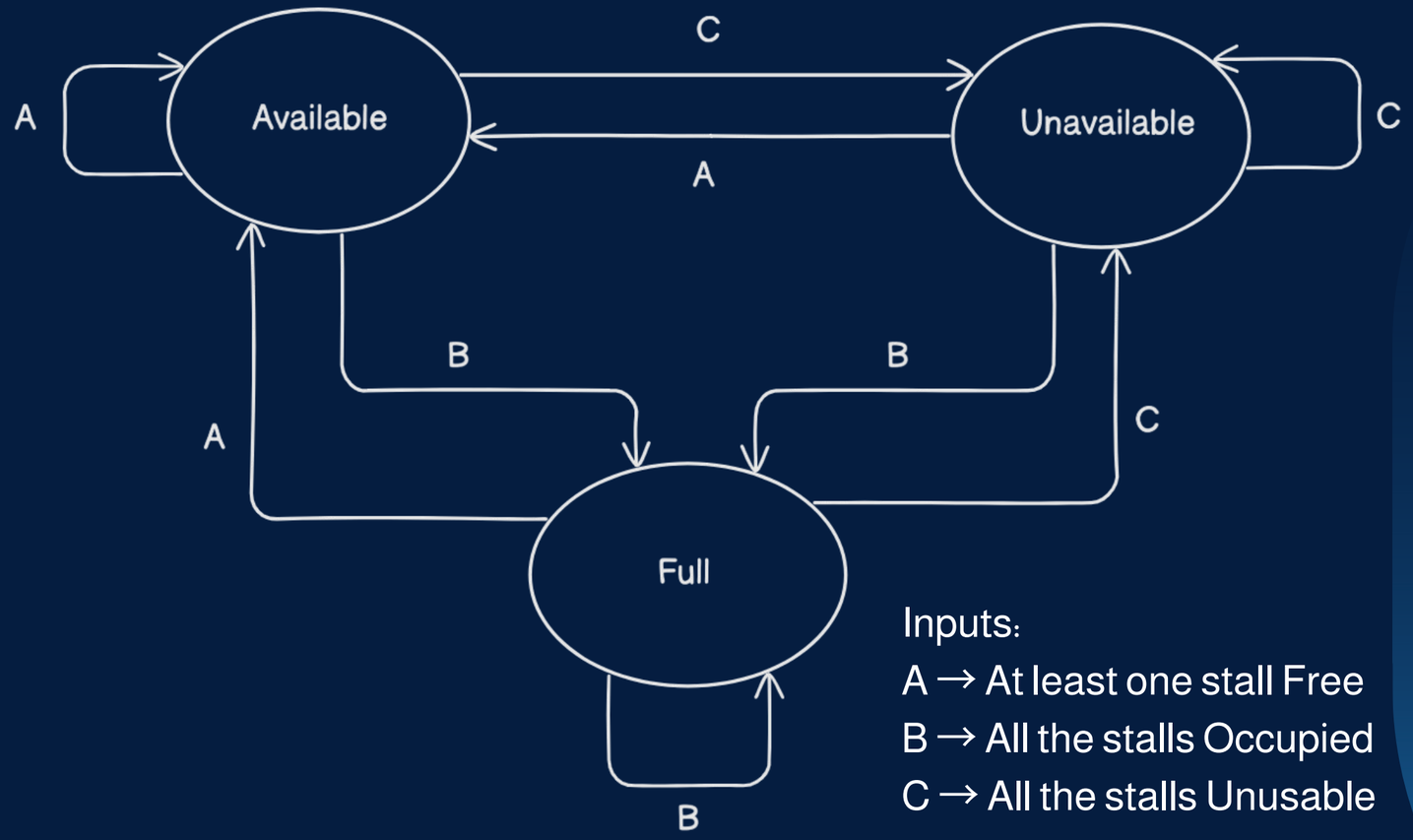
WHY SHOULD OUR DIGITAL TWINS COMMUNICATE WITH EACH OTHER?

BATHROOM FINITE STATE MACHINE

Stalls communicate to change the state of the whole bathroom.

When state is **Unavailable**:

- A suggestion to use another bathroom is sent to the user.
- The operator receives an alert about the issue.

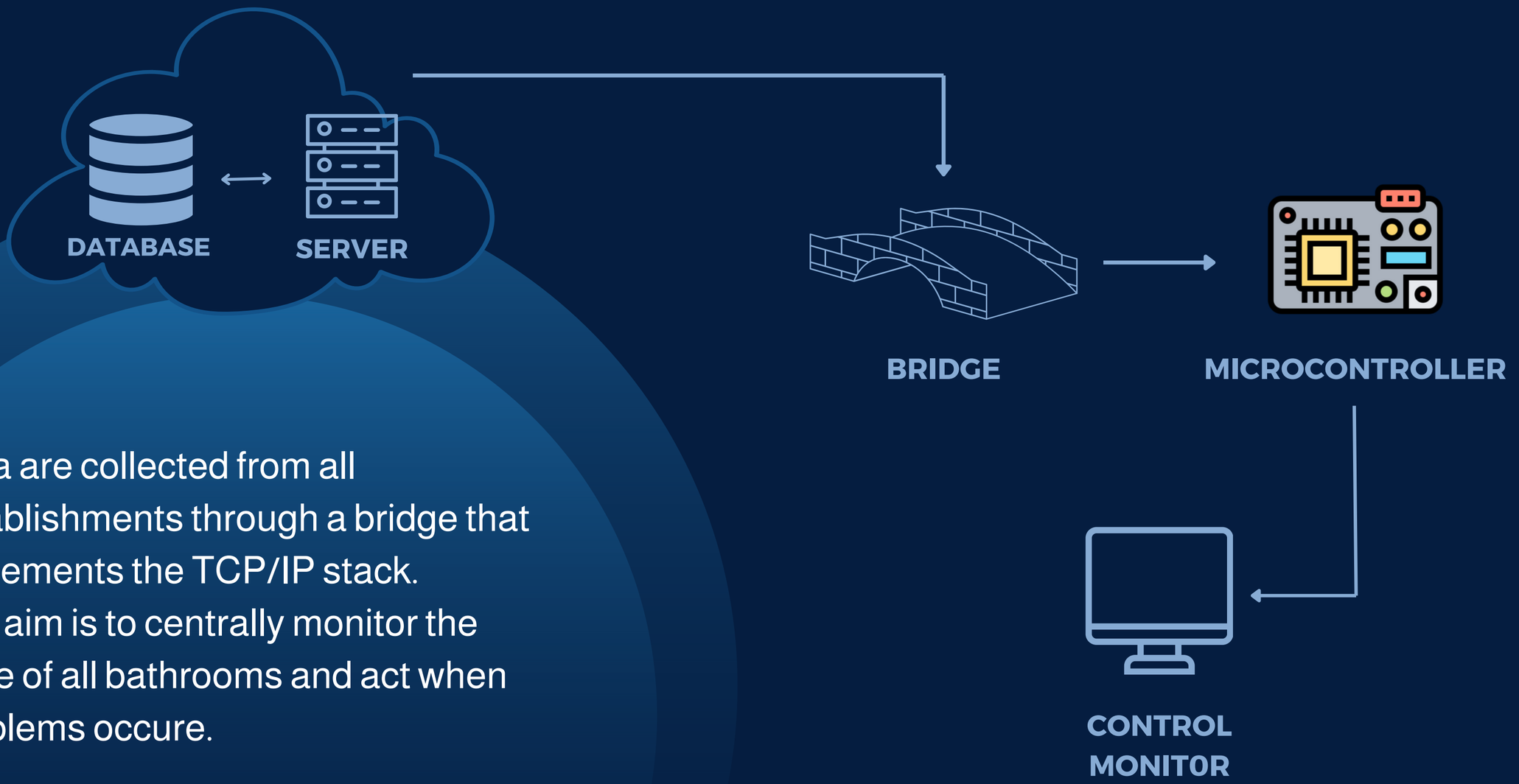


Inputs:
A → At least one stall Free
B → All the stalls Occupied
C → All the stalls Unusable

WHY SHOULD OUR DIGITAL TWINS BE ACCESSIBLE REMOTELY?

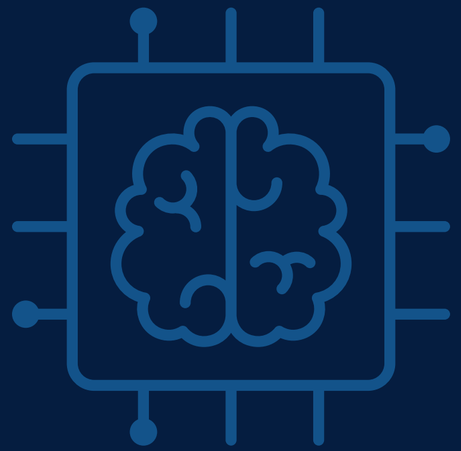
HOW ARE DATA RETRIEVED THROUGH INTERNET?

07



Data are collected from all establishments through a bridge that implements the TCP/IP stack.
The aim is to centrally monitor the state of all bathrooms and act when problems occure.

08 OPTIMIZATION THROUGH AI



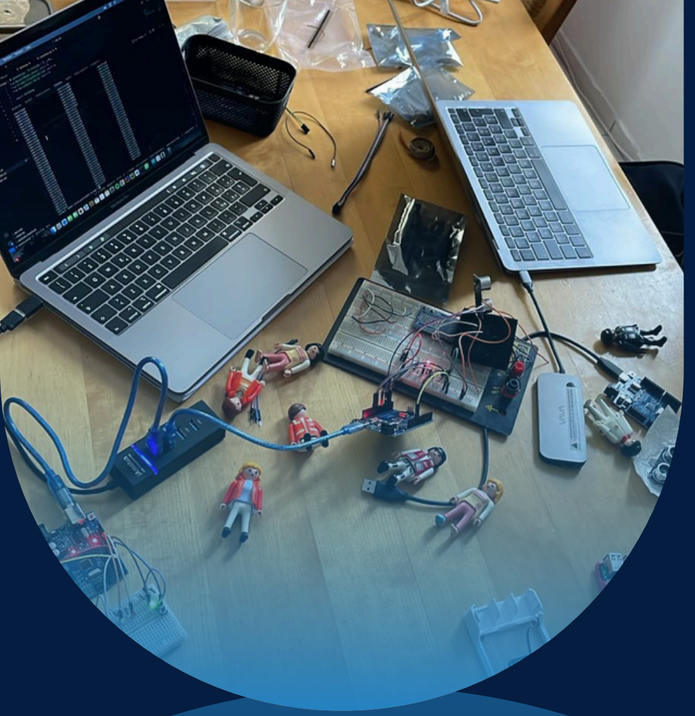
Digital bathrooms are collecting a lot of data

Preprocessing to obtain a suitable dataset

Training the machine learning model

Predict toilet paper consumption, restroom malfunctions, and usage over time

OUR PROTOTYPE

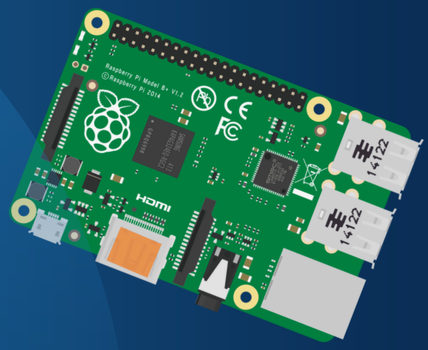


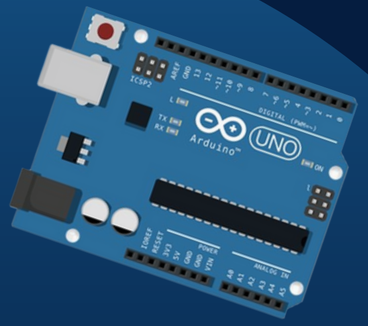
WEBCAM

The two cameras collect images of playmobil figurines inside the bathrooms

RASPBERRY PI

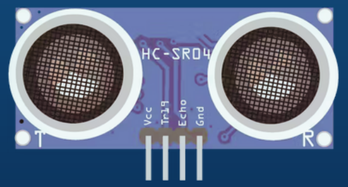
Acts as a bridge together with a computer





ARDUINO

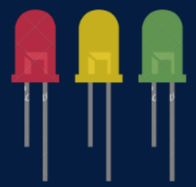
Four arduino, one for each stall
One wifi arduino for remore control



ULTRASONIC SENSORS

Four sensors, one for each stall, used for occupancy
Two sensors used for the computation of toilet paper percentage

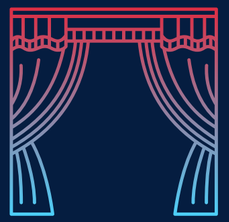
DATA FLOW



Arduino transmits its state and the percentage of toilet paper in real-time using the **JSON** format over **serial.**

The bridge collects all the stalls data and performs **object detection** counting the figurines in the queue. The information is sent via **HTTP protocol** to the Thingsboard server.

ThingsBoard records bathroom telemetry, storing **historical data** in the database.



The data is displayed in both the application and the remote control interface.

OBJECT DETECTION

The model used is YOLO 11, which has been fine-tuned to recognize Playmobil figurines.

- **Dataset**: created and annotated using Roboflow
- **Training**: performed on Google Colab

The fine-tuned model is integrated into the Python application running on the bridge, and images are captured using the OpenCV library.

THINGSBOARD

IoT platform that manages the data from sensors installed in the bathrooms.

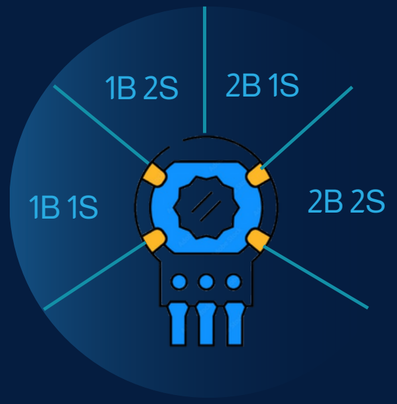
- Provides API support for external GET and POST requests.
- Generates dashboards and sends an email if a certain bathroom is Unavailable.
- Thanks to the database history and the platform's CSV feature, it is possible to create a dataset for AI applications.

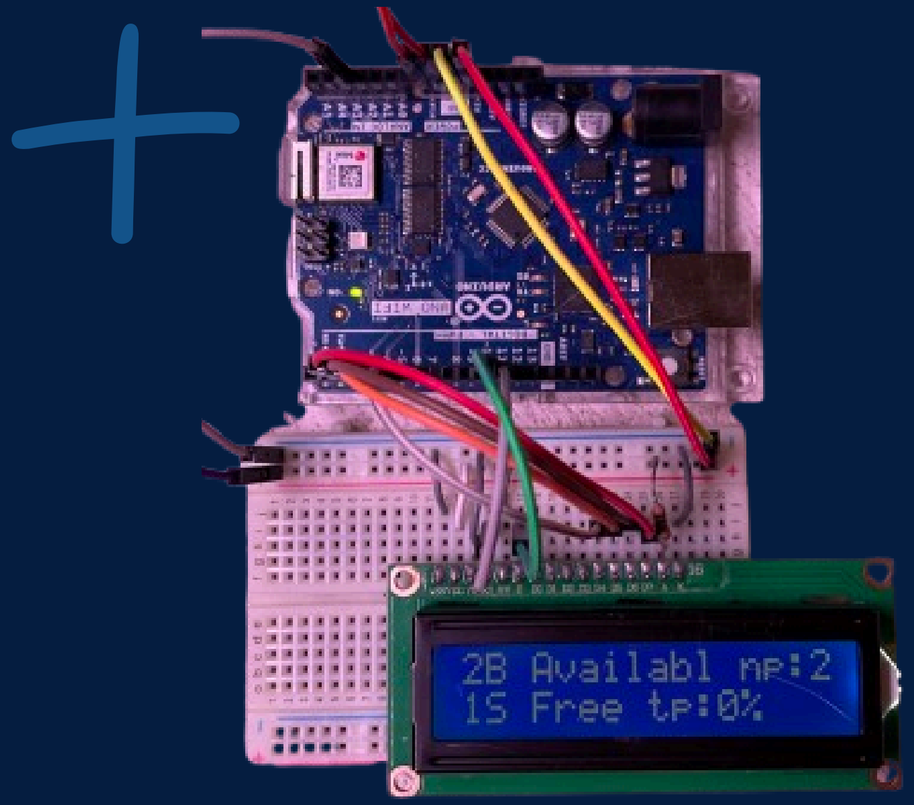
CONTROL ROOM

Simulation through a display

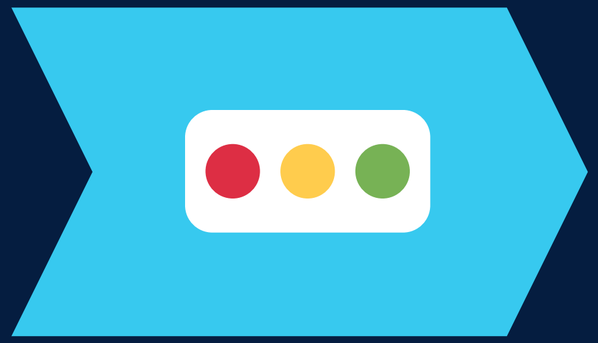
Arduino wifi works both as the microcontroller and the bridge, its only function being to retrieve data via GET request.

A **16x2 LCD display** is used to showcase information about an individual stall, while a **potentiometer** allows selection of the desired one.





MIT APPLICATION



Bathroom and stall labels are updated regularly via GET requests, changing colors to display states.

Notifications are sent when a bathroom becomes Unavailable. Additionally, the operator can specify the nature of a problem in each stall: the state can be set to Maintenance or Cleaning.

Feedback of the user is recorded with a five star system.

THANK YOU FOR THE ATTENTION

ALESSIA CORNI

MATTEO GOMBIA

MARIANNA SOLMI