IoT & 3D Intelligent Systems project
University of Modena and Reggio Emilia

UNIMORE

SMASHBOX

Simone Bugo
Francesco Marzo

SMASHBOX

who we are

We are two students of Artificial Intelligence Engineering, passionate about technological innovation, security systems, and the future of smart infrastructures.

Francesco Marzo

Simone Bugo

The Birth of SMASHBOX

Driven by a shared vision to revolutionize traditional banking security, we created SMASHBOX: an intelligent, interconnected, and biometrically secured system of safe deposit boxes

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State of the art

safety deposit box systems are obsolete

Once customers enter into a lease agreement for a safe deposit box, a physical key is assigned to them and this could lead to several problems

The key could be lost

The bank cannot retain a copy of the key due to privacy regulations, complicating the recovery process

No intercommunication between boxes

every box is separated from the others, if one of them has been compromised the other are not informed

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security problems

current security technology

- boxes are located in vault rooms
- boxes are closes through physical key
- vault rooms are protected by alarms and security cameras

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problems

- no alarm for a single box
- no intercommunication between all the boxes
- lack of control on box parameters

So we thought about a possible solution...

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Secure Monitoring And Smart Hub for Biometric Optical boXes

SMASHBOX vision

“SMASHBOX is redefining the traditional concept of bank safe deposit boxes, transforming them into intelligent, interconnected, and biometrically secured systems.
We are moving beyond static, conventional storage models to usher in a new era of dynamic, personalized, and digitally enhanced security.”

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key point

Innovators in Security Technology

We combine advanced sensor networks, biometric authentication, and smart connectivity to revolutionize traditional safe deposit boxes.

Bridging Physical and Digital Worlds

Our solutions connect physical security infrastructure with real-time digital monitoring, empowering customers with greater control and awareness.

Focused on Personalized Safety

SMASHBOX offers a user-centric experience: each safe deposit box is individually monitored, alert-enabled, and biometrically protected.

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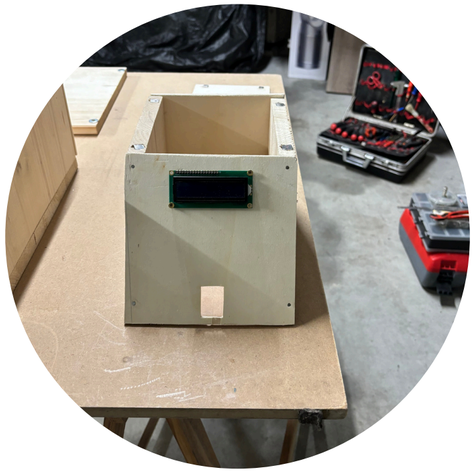
Our Product

SmashBox is composted by two main physical parts:

- One central part which is used by the bank operator
- Many acquisition boxes which are assigned to the clients



central

boxes

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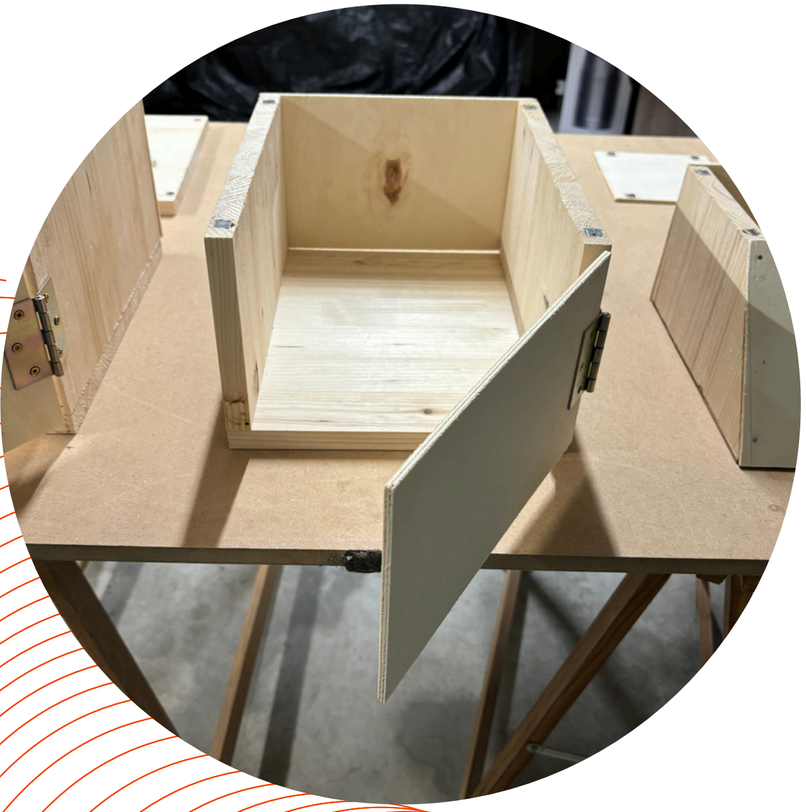
Our Product

Acquisition description



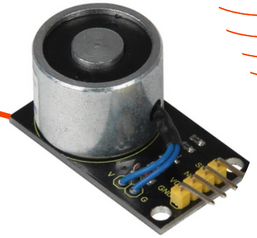
components inside Acquisition

Arduino Uno

Adafruit_AHT25

ADXL345

2x IR-SENSOR



SEN-MAG25N

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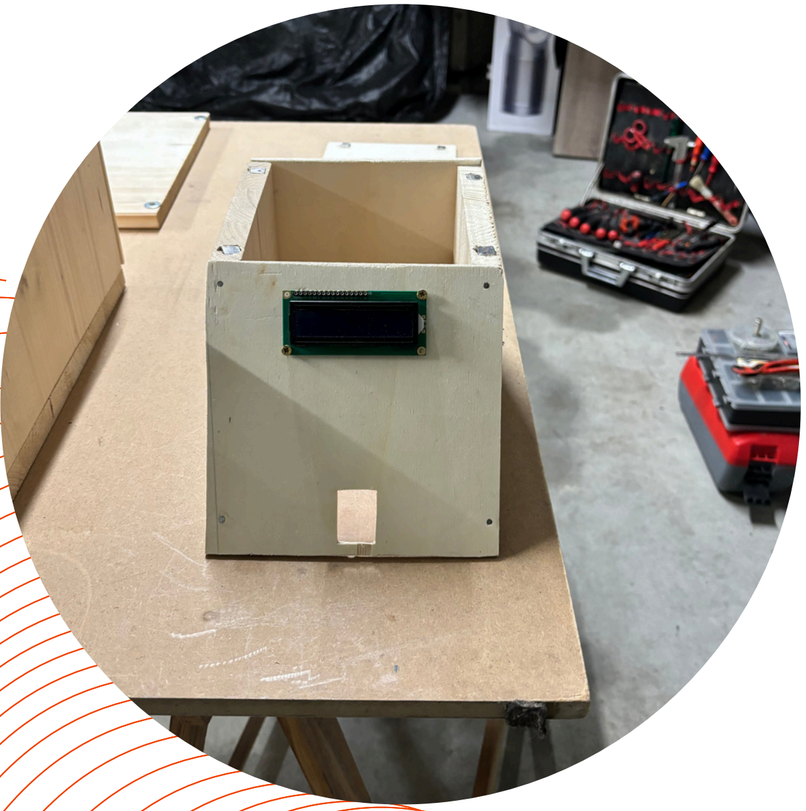
Our Product

Central description

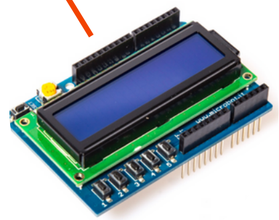


components inside Central

Arduino Uno

Button

JM-101



Display LCD

How does it work?

Registration process of new fingerprints

Unlock process of registered fingerprints

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Telegram Bot

The Telegram bot acts as a secure endpoint for communication between the system and the user.

Real-time notifications:

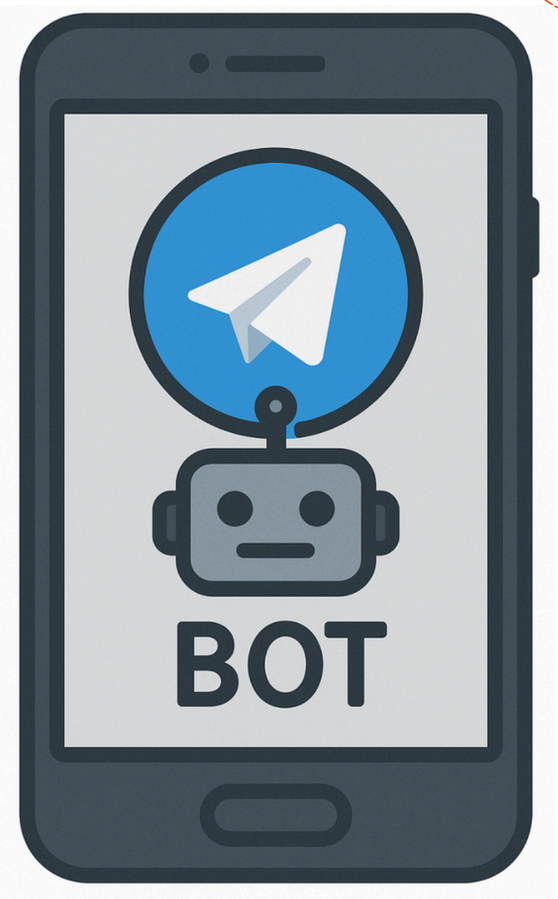
- Opening of the personal safe deposit box
- Alerts or anomaly reports

Activity history available:

- The user can query the bot to retrieve the log list related to their box

Advantages:

- Instant communication
- Simple and direct interaction
- Increased transparency and security



Architecture

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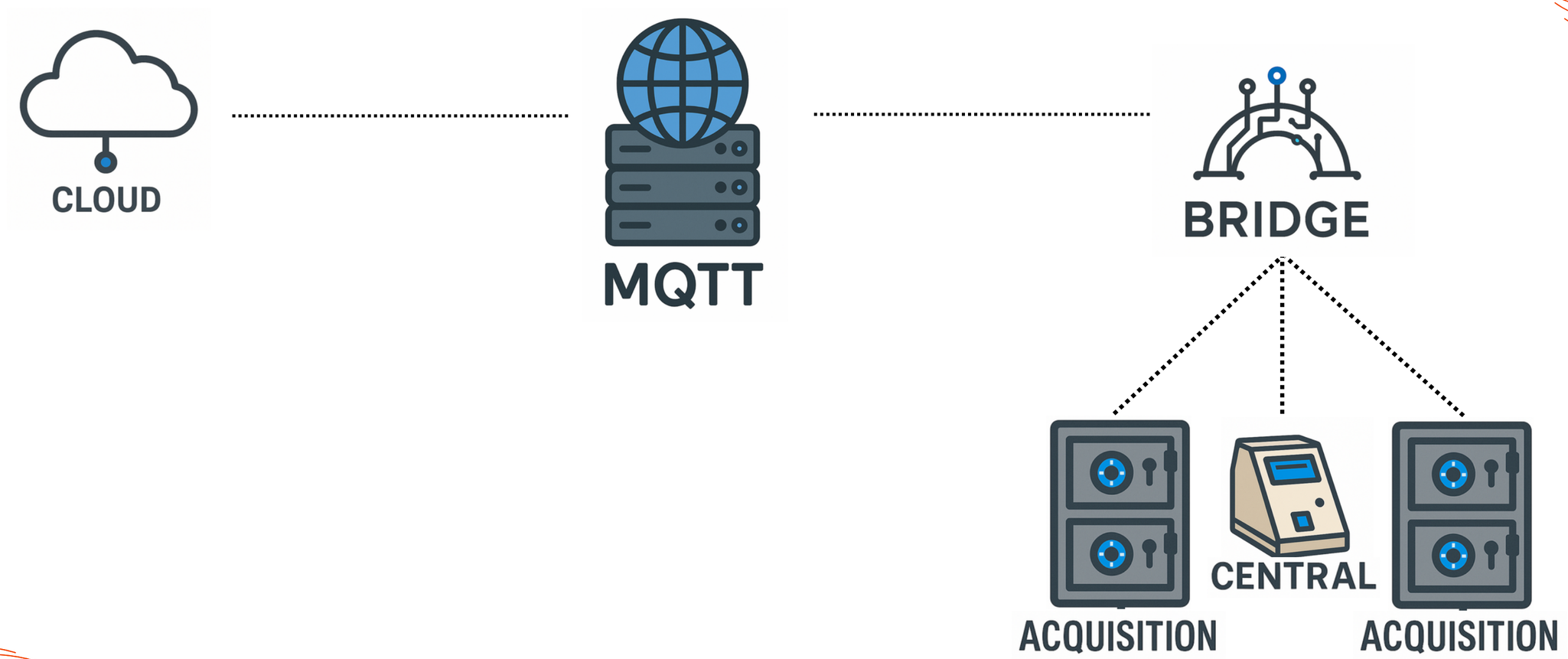
Architectural schema



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Bridge

The Bridge is a Python script that performs multiple functions:

2. It manages bidirectional communication between:

- **LOCAL (receives data from Arduino)**
- **CLOUD (sends data to the Cloud / receives commands)**

2. It uses a Parser to:

- **Unpack the data**
- **Perform HTTP/MQTT updates**

3. It functions as a central node between:

- **CENTRAL (control logic)**
- **Multiple ACQUISITIONS (sensor boxes)**

4. In case of a critical event (Safe Mode):

- **The Bridge propagates the command to all the boxes**

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Cloud Platform

ThingsBoard

Thingsboard is the chosen Platform for Remote Monitoring

Main Features:

- **Representation of each box through a Digital Twin**
- **Real-time data visualization (charts, statuses)**
- **Automatic triggers in response to received events**
- **Manages the propagation of Safe Mode**

A server hosting an MQTT broker has been added to enable communication between BRIDGE and ThingsBoard.
The BRIDGE subscribes to alarm topics published by the system via this broker (e.g. test.mosquitto.org).
This setup is required because the free version of ThingsBoard supports only inbound data.

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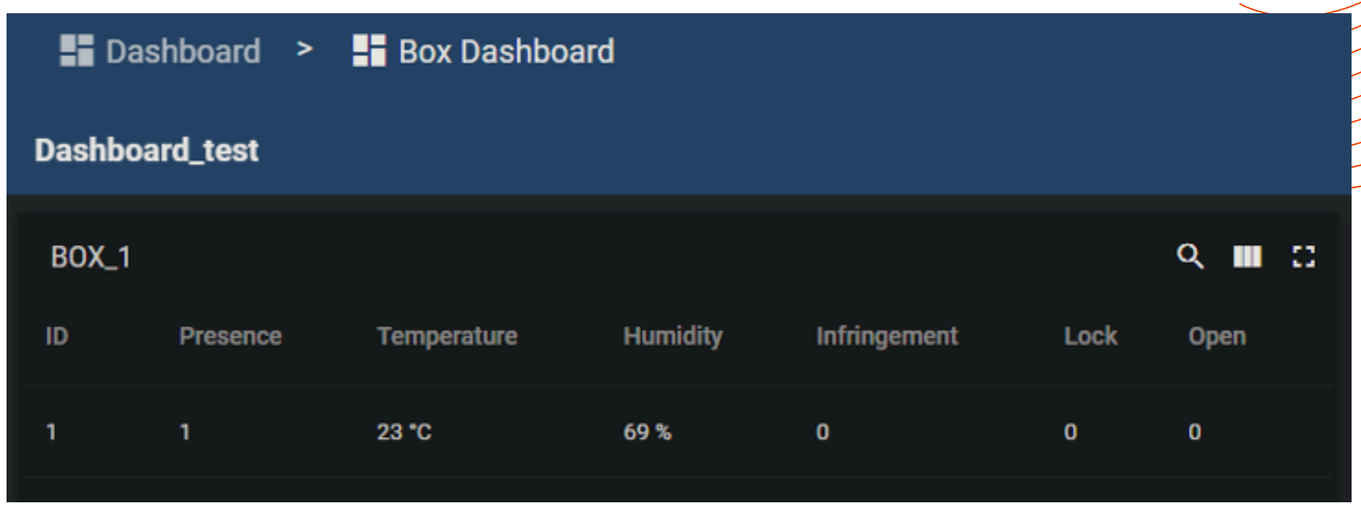
Cloud Platform

During the prototyping phase:

- Two virtual devices were created on the platform
- Each device was configured with a unique access token for communication via the integrated MQTT broker
- Devices periodically transmitted simulated sensor data, emulating real-world input

A custom dashboard was developed to:

- Display data in real time
- Facilitate continuous monitoring of device status
- Support debugging activities during development



Cloud Platform

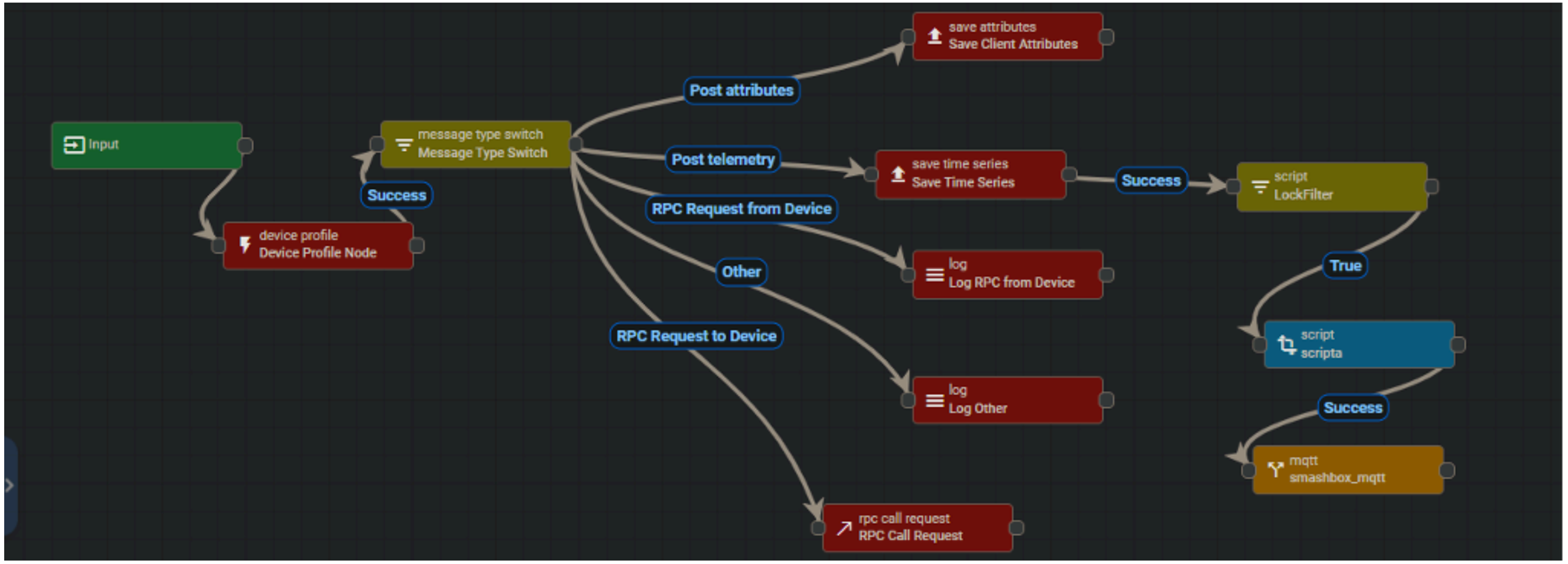
A Rule Chain was implemented to define trigger conditions based on predefined threshold violations

When an alarm condition is detected:

- **The Rule Chain generates an outgoing MQTT message**
- **The message is sent to an external broker (Mosquitto)**

The Bridge, subscribed to the external Mosquitto broker:

- **Receives MQTT alarm messages**
- **Executes corresponding actions based on the notification**



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system analysis (high level)

Startup Process:

- **Initialization: ACQs and CNTRL enter standby mode.**
- **Connection: Devices connect to the Bridge.**
- **Assignment: Bridge recognizes all the units.**
- **Enroll: Bridge enable central to start enroll fase.**
- **Identification: each boxes registered get an id.**

Normal Operation (IDLE Mode):

- **ACQs collect environmental & security data.**
- **Data is sent → Bridge → Server.**
- **Boxes can be unlocked via registered fingerprints.**

Alarm Mode (SAFE MODE):

- **Triggered by:**
  - **Unauthorized opening**
  - **Physical shock**
  - **Abnormal temperature/humidity**
- **System response:**
  - **Local alerts (LEDs, locks)**
  - **Notification sent to Telegram Bot**

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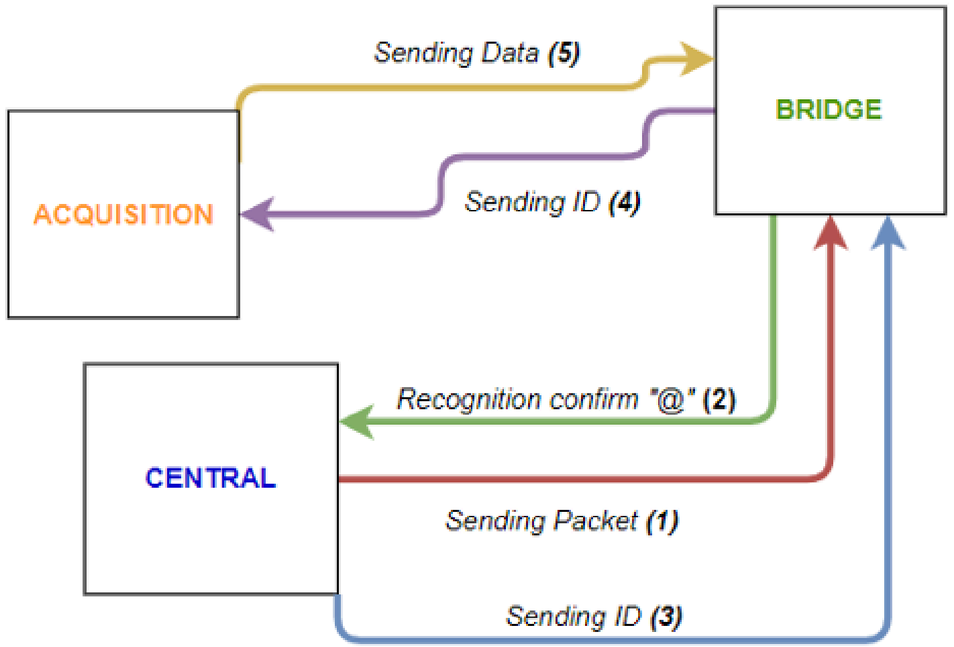
Technical analysis

Start Up Phase

Start Up phase is composted by 2 sub-phases:

- **Recognition →bridges identifies which serial port is connected to central and acquisitions**
- **Enroll → assignment of an id based on the registered fingerprint to a box**



1) CNTRL -> BRIDGE: 7-byte packet: 0x00
2): BRIDGE-> CNTRL : 1-char "@"
3) CNTRL -> BRIDGE: 2-byte pkt (header, data)
4) BRIDGE-> ACQ: 10-byte pkt (id)
5) ACQ-> BRIDGE 7-byte pkt (data acquisition)

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Technical analysis

Acquisition protocol

After receiving its unique ID from the CNTRL, each ACQ continuously acquires data in real-time from sensors installed inside the boxes:

- **Temperature & Humidity**
- **Accelerometer**
- **Object presence**
- **Door open/close status**

At the end of each acquisition cycle, the ACQ sends a 7-byte data packet via serial to the BRIDGE. This loop runs continuously.

ID (1 Byte)	Presence (1 Byte)	Temperature (1 Byte)	Humidity (1 Byte)	Infraction (1 byte)	Lock (1 byte)	Open (1 byte)

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Technical analysis

Acquisition protocol

Normal Mode:

- **The 7-byte packet contains the actual sensor data acquired during the cycle. The BRIDGE then forwards this data to the server.**

SAFE MODE:

- **All 7 bytes are set to 0, except for the “Lock” field, which is set to 1. (0000010)**
- **This packet is sent repeatedly until SAFE MODE is exited.**

45	0	22	46	0	1	0
0	0	0	0	0	1	0

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Technical analysis
Central Protocol

CNTRL sends action requests to BRIDGE via a 2-byte ACTION_PACKET:

- **1 byte for action header**
- **1 byte for action data**

If no action is needed, CNTRL sends a cyclic IDLE packet:

- **Header: PACKET_IDLE, Data: 0**

3 Action Modes:

1. **Enroll mode**
2. **Fingerprint Mode**
3. **Check Mode**

Enroll Mode	FIngerprint Mode	Check Mode
• Final step of setup(): waits for 2 fingerprint registrations • Sends ACTION_PACKET with header PACKET_ENROLL + random ID • BRIDGE forwards a 10-byte packet to ACQ	• Default listening state for new fingerprint input	• Triggered when a finger is placed • If matched, sends ACTION_PACKET with header PACKET_CHECK + recognized ID • Display shows unlocked Box ID

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Technical analysis

Safe Mode Protocol

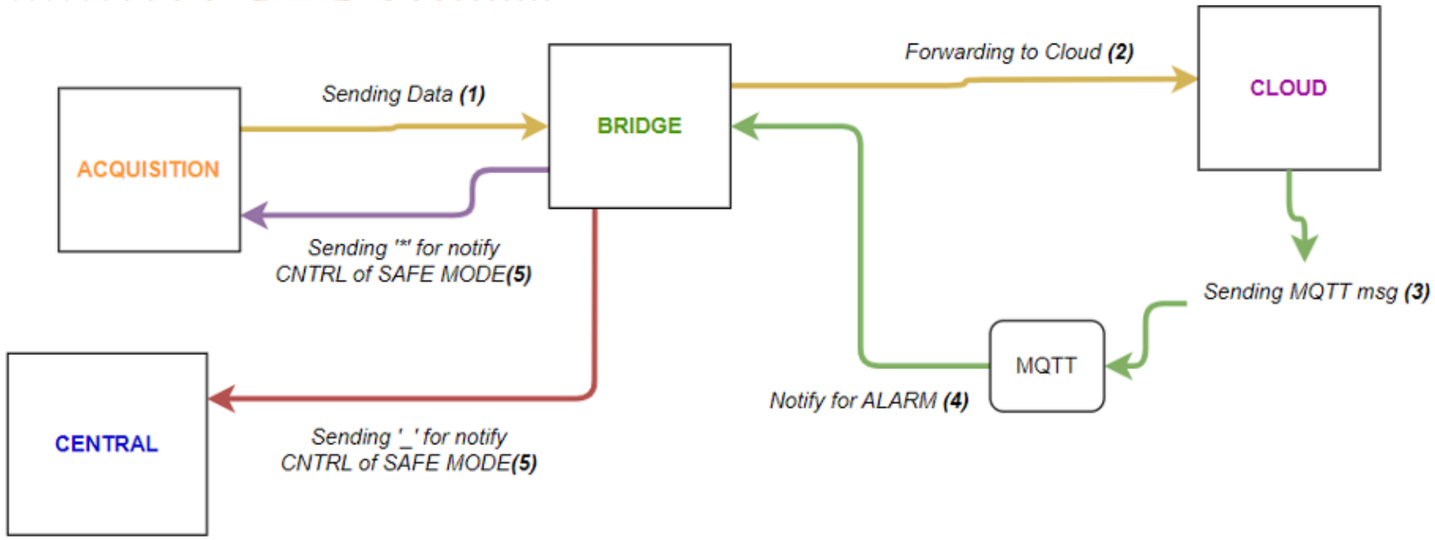
Mode triggered by the server

When ACQ data reaches the server, it is processed in real time.If any of the following conditions are detected:

- **Tampering (via accelerometer)**
- **Temperature or humidity exceed predefined thresholds**

Then:

- **A message is sent via MQTT broker to the BRIDGE**
- **The BRIDGE notifies the entire "local" subsystem: Both CNTRL and ACQ components**



1) CNTRL -> BRIDGE: 7-byte packet with "infra" set
2): BRIDGE-> CLOUD: 7-byte packet with "infra" set
3) CLOUD-> BRIDGE: MQTT msg
4) CLOUD-> BRIDGE: MQTT msg
5) BRIDGE-> CNTRL 1 char '_' to notify CNTRL
5) BRIDGE-> ACQ 1 char '*' to notify ACQ