

Applying Embedded Multi-Agent Systems to Landslide Monitoring

Students: Gabriel Almeida Klein, Matheus de Souza Perdigão Silva and Washington Alves Pedro.

Advisor: Nilson Mori Lazarin

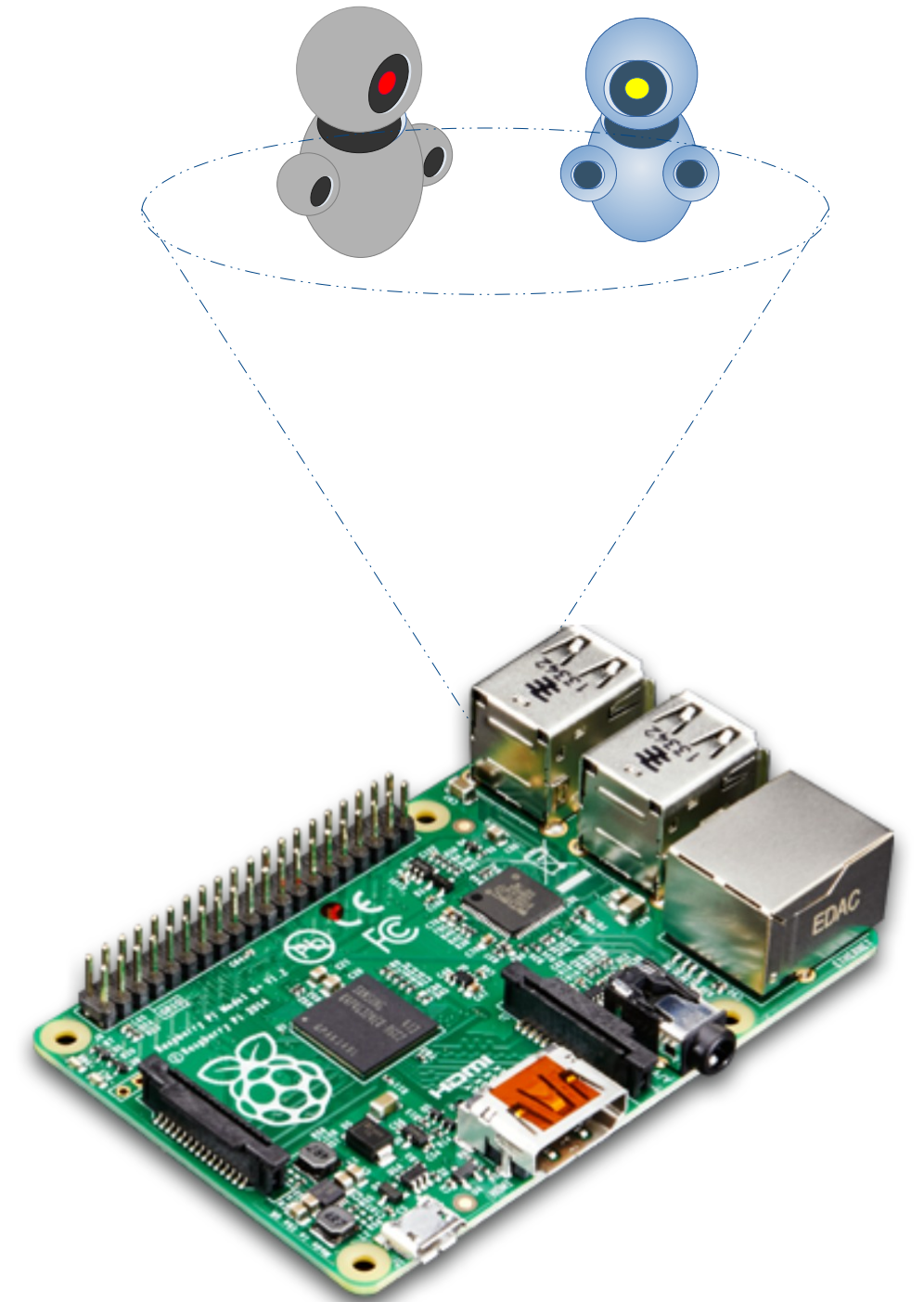
BACKGROUND

- The mountains of Rio de Janeiro are prone to landslides due to their geology and high rainfall rates;
- The region has already experienced major disasters, such as the one in Nova Friburgo in 2011. The UN classified it as the eighth largest disaster of its kind in the last century;
- More than 50% of the state of Rio de Janeiro is at risk of landslides. They occur frequently during rainy seasons.

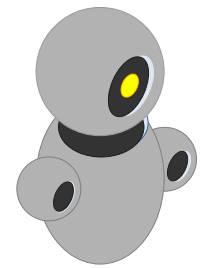


PURPOSE OF THE STUDY

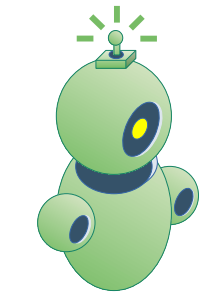
Exploration of the application of Embedded Multi-agent Systems for the monitoring of landslide-prone areas without human intervention;



THEORETICAL FOUNDATION



Jason agent is a common agent that develops its reasoning process based on information provided by the environment, its desires and beliefs, and messages received from other agents.



Communicator agent is an extension of a Jason agent, with the ability to communicate with agents from other external MAS, in addition to moving to other MASs, through an IoT network.



ARGO agent, in turn, has the ability to manifest itself in the physical environment, perceive information and modify it, via sensors and actuators connected to a microcontroller.

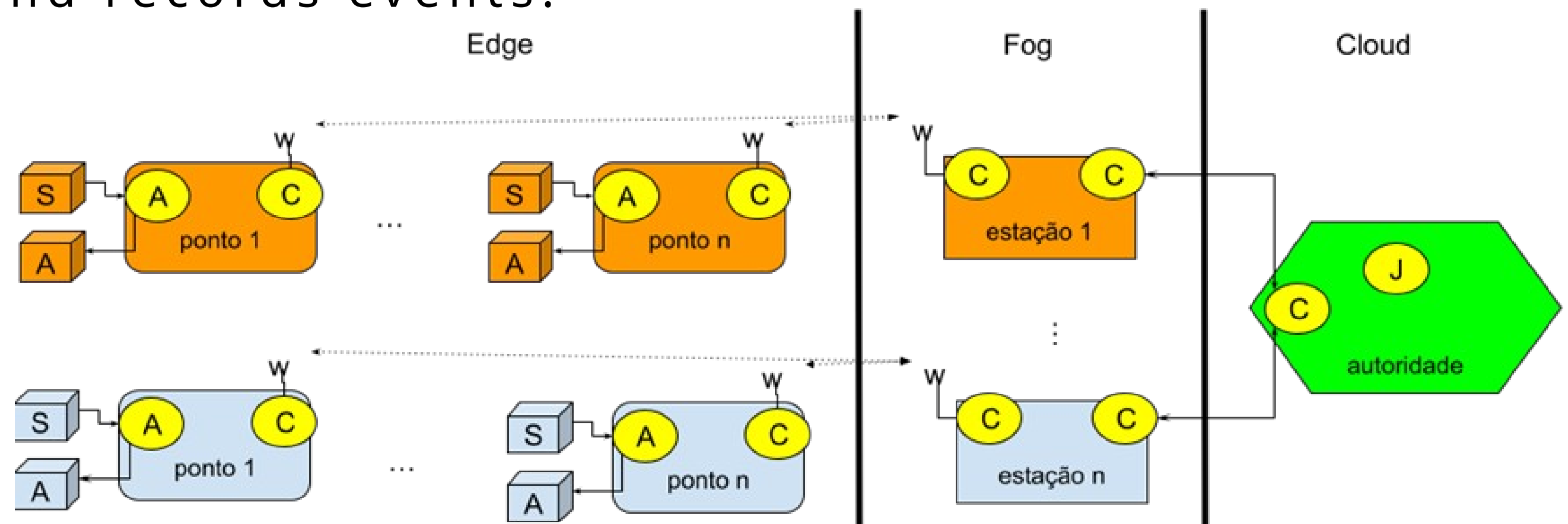
PROPOSED ARCHITECTURE

- Use MAS in three computing layers:

Edge Computing: Embedded MAS sensing and acting in the physical environment.

Fog Computing: MAS filter perceptions and coordinate actions within monitored areas.

Cloud Computing: A cloud-based MAS coordinates multiple monitoring areas and records events.

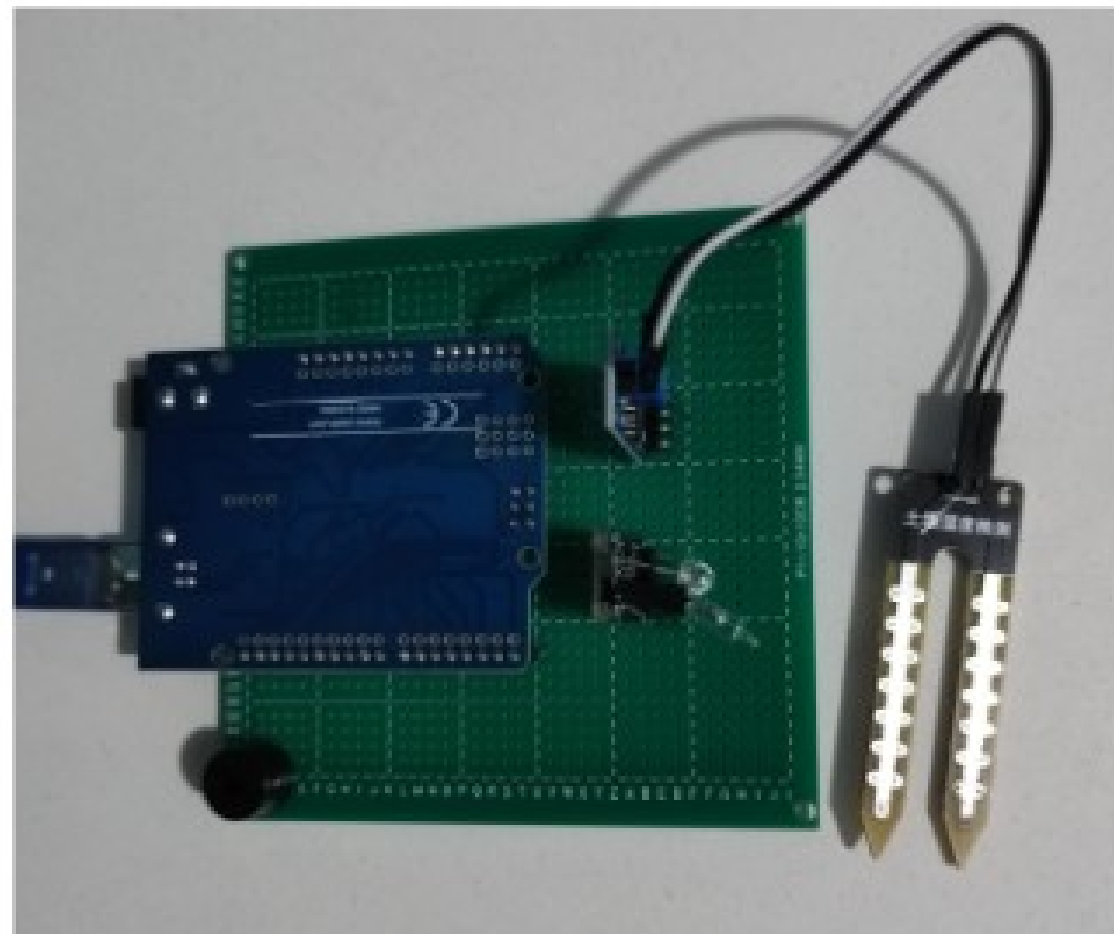


RESOURCE PROTOTYPE

Hardware capable of manifesting the agent's capabilities in the exogenous environment to be connected to the embedded MAS at the monitoring point;

Sensors and actuators connected to an Arduino platform.

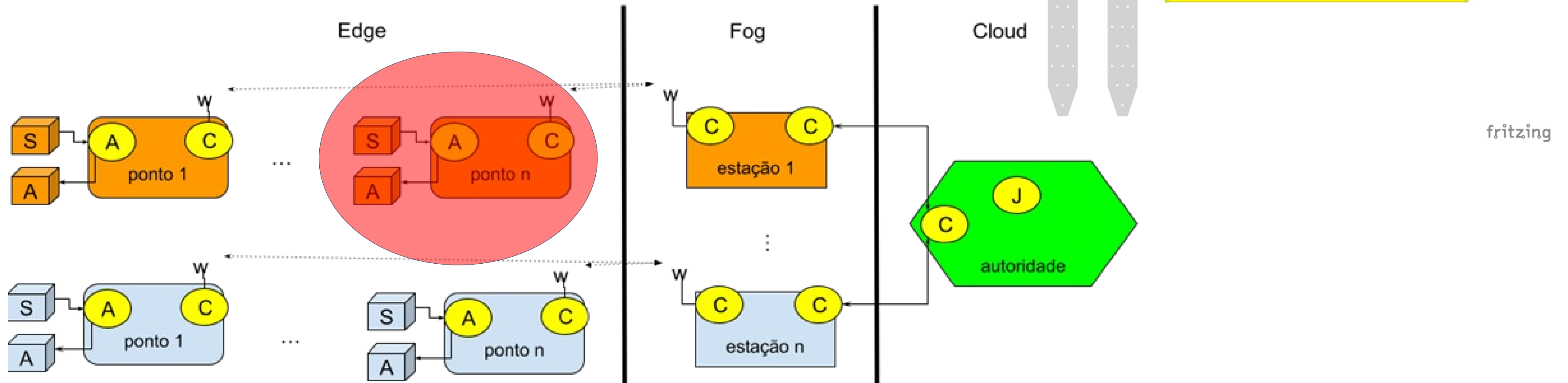
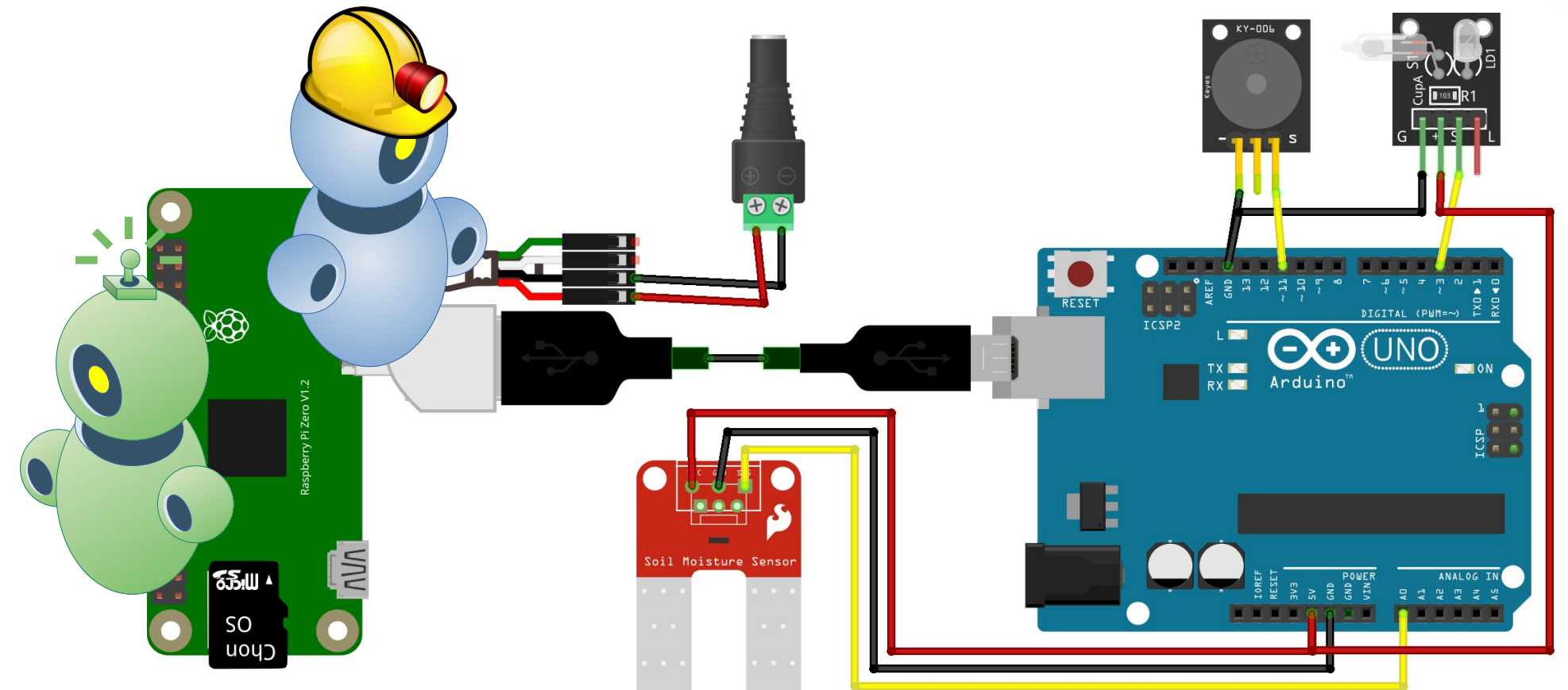
Firmware programmed using the Javino library.



Ações suportadas	
perigo	Ativa o <i>buzzer</i> emitindo um apito a cada 1 segundo.
critico	Ativa o <i>buzzer</i> emitindo um som de sirene.
desativar	Desativa o <i>buzzer</i> .
Percepções informadas	
umidade(N)	N é um inteiro (entre 0 e 100).
movimento(T)	T é um termo (<i>true</i> ou <i>false</i>).

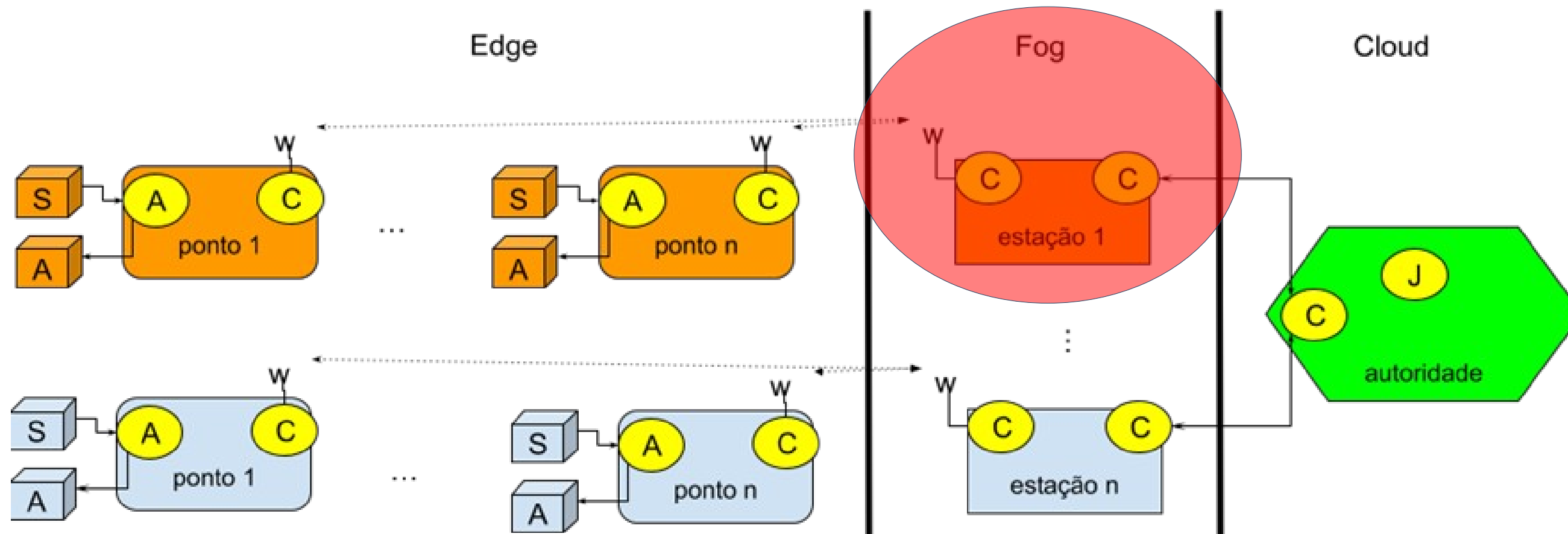
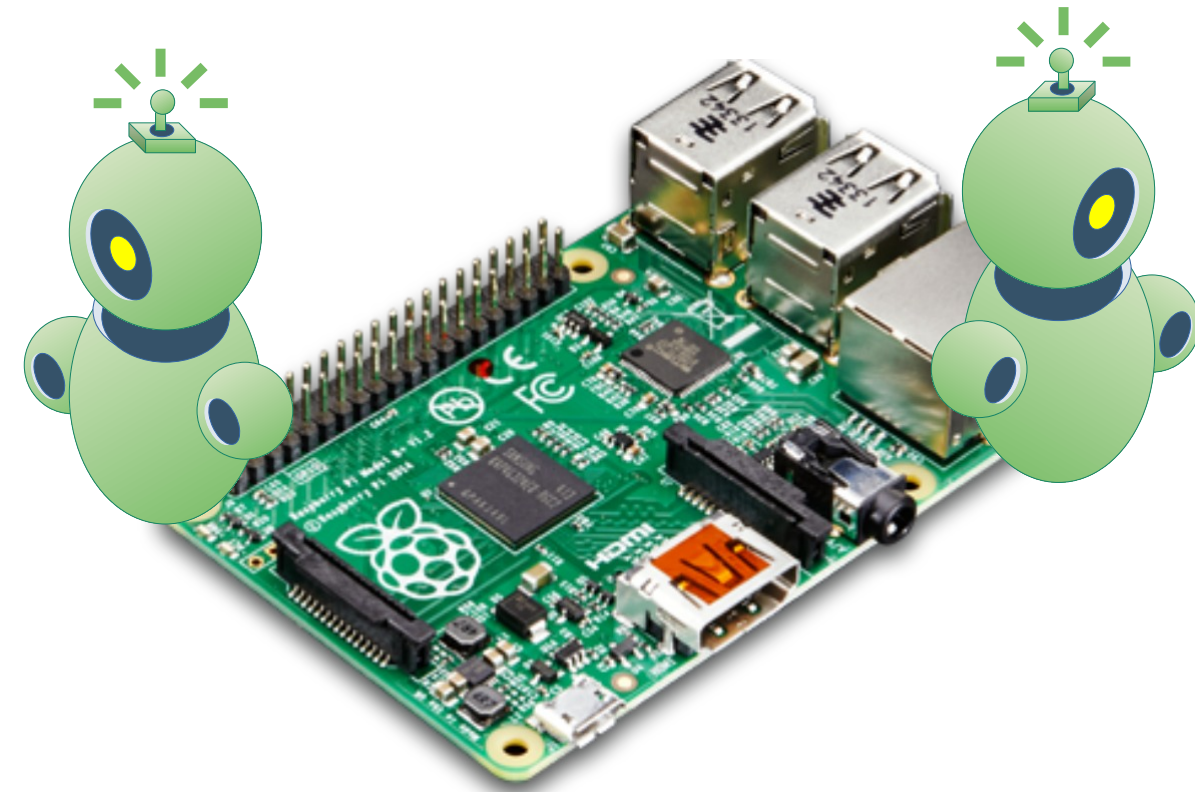
IMPLEMENTATION

- A Raspberry Pi Zero W
- running chonOS was used
- to embed the MAS to the
- monitoring point.



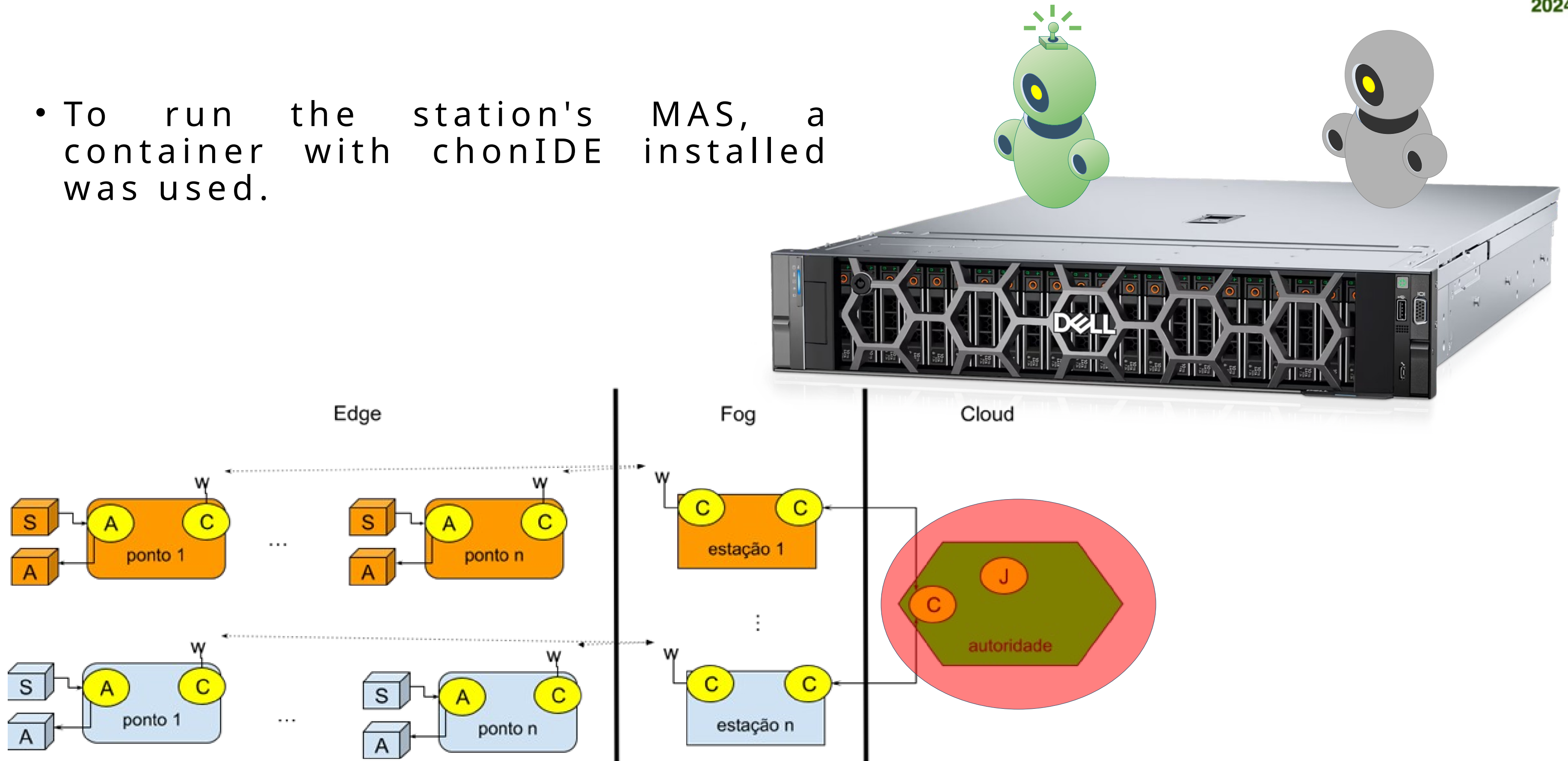
IMPLEMENTATION

- To run the station's MAS, a Raspberry Pi 3 Model B was used, also running chonOS.



IMPLEMENTATION

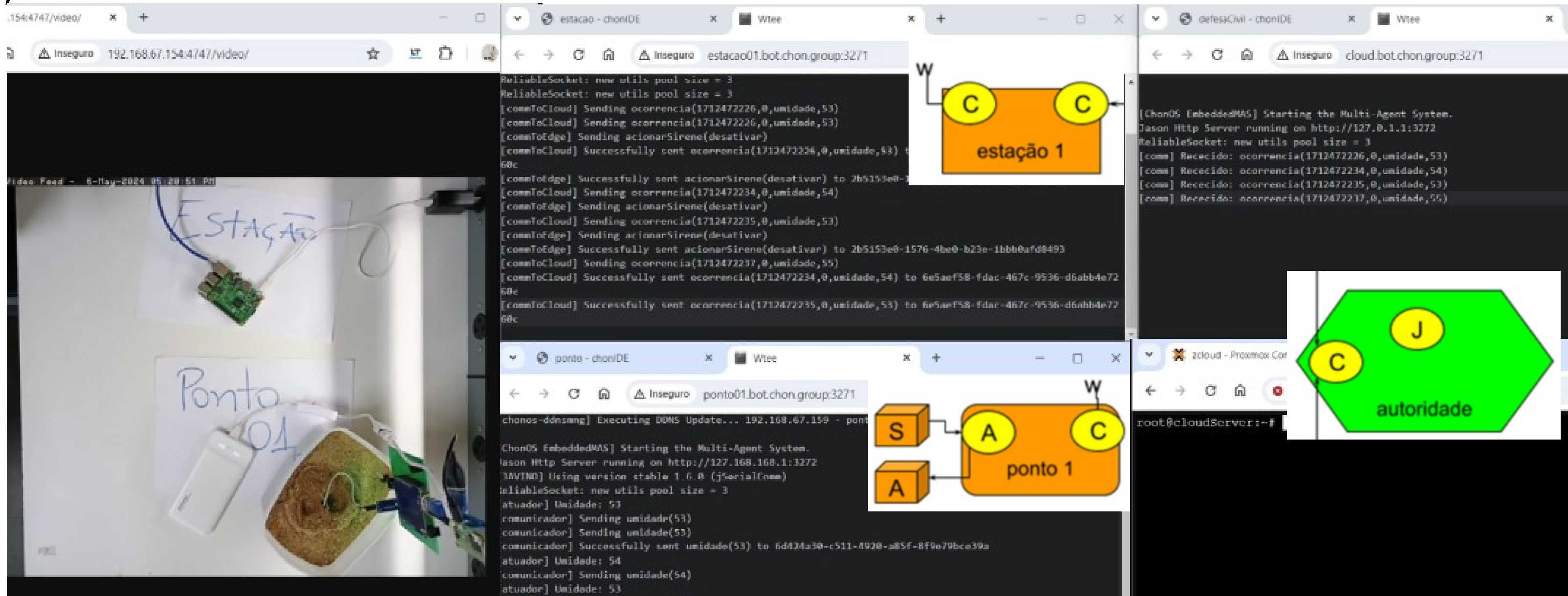
- To run the station's MAS, a container with chonIDE installed was used.



SCENARIO

Jason agent in supervisor's MAS makes decisions based on four scenarios:

1. Humidity between 60-90% → monitoring point at risk → alarm for all monitoring points in the area from which the data was sent;



The screenshot displays a multi-agent system interface with several components:

- Video Feed:** A live video feed of a physical monitoring station labeled "ESTAÇÃO" and "Ponto 01". It shows a green sensor board connected to a white device and a small plant in a container.
- Terminal Logs:** Multiple terminal windows showing system logs and agent communications. Key messages include:
 - "ReliableSocket: new utils pool size = 3"
 - "[commToCloud] Sending ocorrencia(1712472226,0,umidade,53)"
 - "[commToEdge] Sending acionarSirene(desativar)"
 - "[commToCloud] Successfully sent ocorrencia(1712472226,0,umidade,53) to 2b5153e0-1576-4be0-b23e-1bbb0af08493"
 - "[commToEdge] Successfully sent acionarSirene(desativar) to 2b5153e0-1576-4be0-b23e-1bbb0af08493"
 - "[commToCloud] Sending ocorrencia(1712472234,0,umidade,54)"
 - "[commToEdge] Sending acionarSirene(desativar)"
 - "[commToCloud] Sending ocorrencia(1712472235,0,umidade,53)"
 - "[commToEdge] Sending acionarSirene(desativar)"
 - "[commToEdge] Successfully sent acionarSirene(desativar) to 2b5153e0-1576-4be0-b23e-1bbb0af08493"
 - "[commToCloud] Sending ocorrencia(1712472237,0,umidade,55)"
 - "[commToCloud] Successfully sent ocorrencia(1712472234,0,umidade,54) to 6e5aef58-fdac-467c-9536-d6abb4e7268e"
 - "[commToCloud] Successfully sent ocorrencia(1712472235,0,umidade,53) to 6e5aef58-fdac-467c-9536-d6abb4e7268e"
- Network Diagrams:** Two diagrams illustrating the system architecture:
 - Diagram 1:** A central orange box labeled "estação 1" with two yellow circles labeled "C" (Cloud) and a white circle labeled "W" (Wireless) connected to it.
 - Diagram 2:** A central orange box labeled "ponto 1" with two yellow circles labeled "A" (Agent) and a white circle labeled "W" (Wireless) connected to it. Two smaller orange boxes labeled "S" (Sensor) and "A" (Agent) are connected to the "A" circle.
- Terminal Output:** A terminal window on the right shows the system starting: "[ChonOS EmbeddedMAS] Starting the Multi-Agent System. Jason Http Server running on http://127.0.1.1:3272". Below this, it lists received events: "[com] Recebido: ocorrencia(1712472226,0,umidade,53)", "[com] Recebido: ocorrencia(1712472234,0,umidade,54)", "[com] Recebido: ocorrencia(1712472235,0,umidade,53)", and "[com] Recebido: ocorrencia(1712472237,0,umidade,55)".
- Diagram 3:** A green hexagon labeled "autoridade" with a yellow circle labeled "J" (Jason) and a yellow circle labeled "C" (Cloud) inside it.

REPRODUCIBILITY



```
chonIDE ponto ✓
Explorer
  Multi-Agent System
  Agents
    atuator
    comunicador
  Firmware
  comunicador Communicator
1  estacaoUUID("6d424a30-c511-4920-a85f-8f9e79bce39a").
2  myUUID("2b5153e0-1576-4be0-b23e-1bbb0afd8493").
3  gateway("skynet.chon.group",5500).
4
5  !connect.
6
7  +!connect: myUUID(MyID) & gateway(Server,Port)<-
8    .connectCN(Server,Port,MyID);
9    !info(ponto(MyID)).
10
11 +!info(I): .random(ACK) & estacaoUUID(Estacao) <- !info(Estacao,I,ACK).
12
13 +!info(D,I,ACK): not ack(ACK) <-
14   .print("Sending ",I);
15   .sendOut(D,achieve,info(I,ACK));
16   .wait(1000+(4000*ACK));
17   !info(D,I,ACK).
18
19 +!info(D,I,ACK): ack(ACK) <-
20   .print("Successfully sent ", I, " to ",D);
21   -ack(ACK)[source(_)].
```

<https://papers.chon.group/WESAAC/2024/monitoriamentoAreaRisco/>

CONCLUSION AND FUTURE WORK



- The application of embedded MAS was promising for landslide monitoring.
- It is suggested that future studies improve the data collection and analysis of vibrations by using a gyroscope, and integrate rain gauges to monitor precipitation levels.
- Additional alerting systems can be implemented, such as mailer agents with the ability to send emails or SMS.

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