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Title: Hardware and software system for simulation, control, and communication between industrial automation programs and PLC control used in educational institutions

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PRESENTATION CONTENT

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Introduction

Industrial automation has radically transformed the production of goods, driving efficiency, productivity, and quality across a wide range of sectors [1]. Industrial automation is a catalyst for productivity and efficiency.

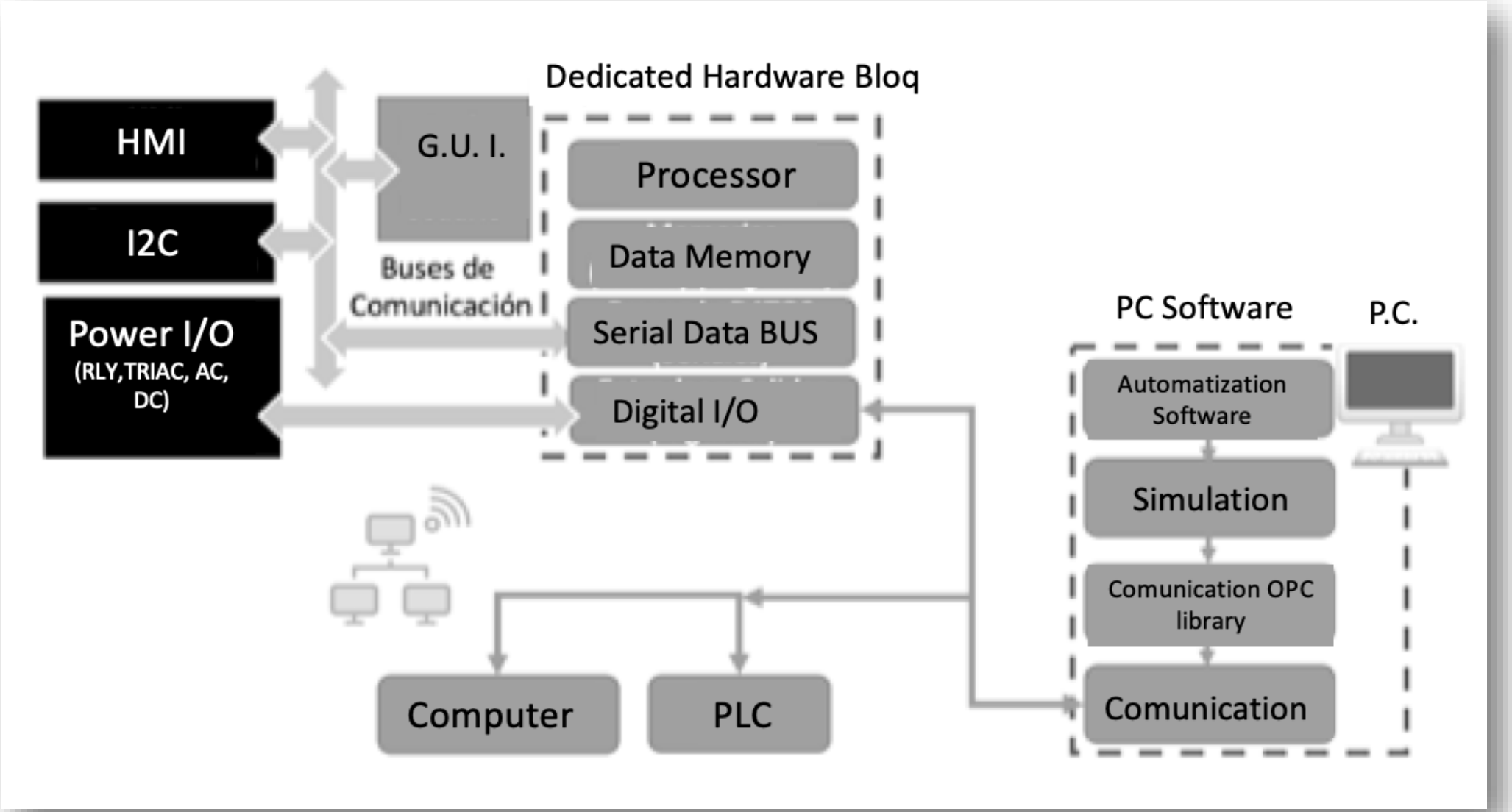
By optimizing processes, reducing costs, and minimizing errors, businesses can improve their competitiveness and offer higher quality products and services at more affordable prices [2]. With the correct implementation of all automation processes, workplace safety is also improved by reducing workers' exposure to dangerous and repetitive tasks [3]; furthermore, by optimizing energy and resource consumption, it is possible to help promote or contribute to sustainability and reduce the environmental impact of industrial operations [4].

The demand for professionals in industrial automation is booming, from design engineers and PLC programmers to maintenance technicians and robotics specialists, job opportunities are diverse and span a wide range of sectors, including manufacturing, energy, food and beverage, pharmaceuticals, logistics, and many more [2]. To master the field of industrial automation, it is essential to understand key concepts such as:

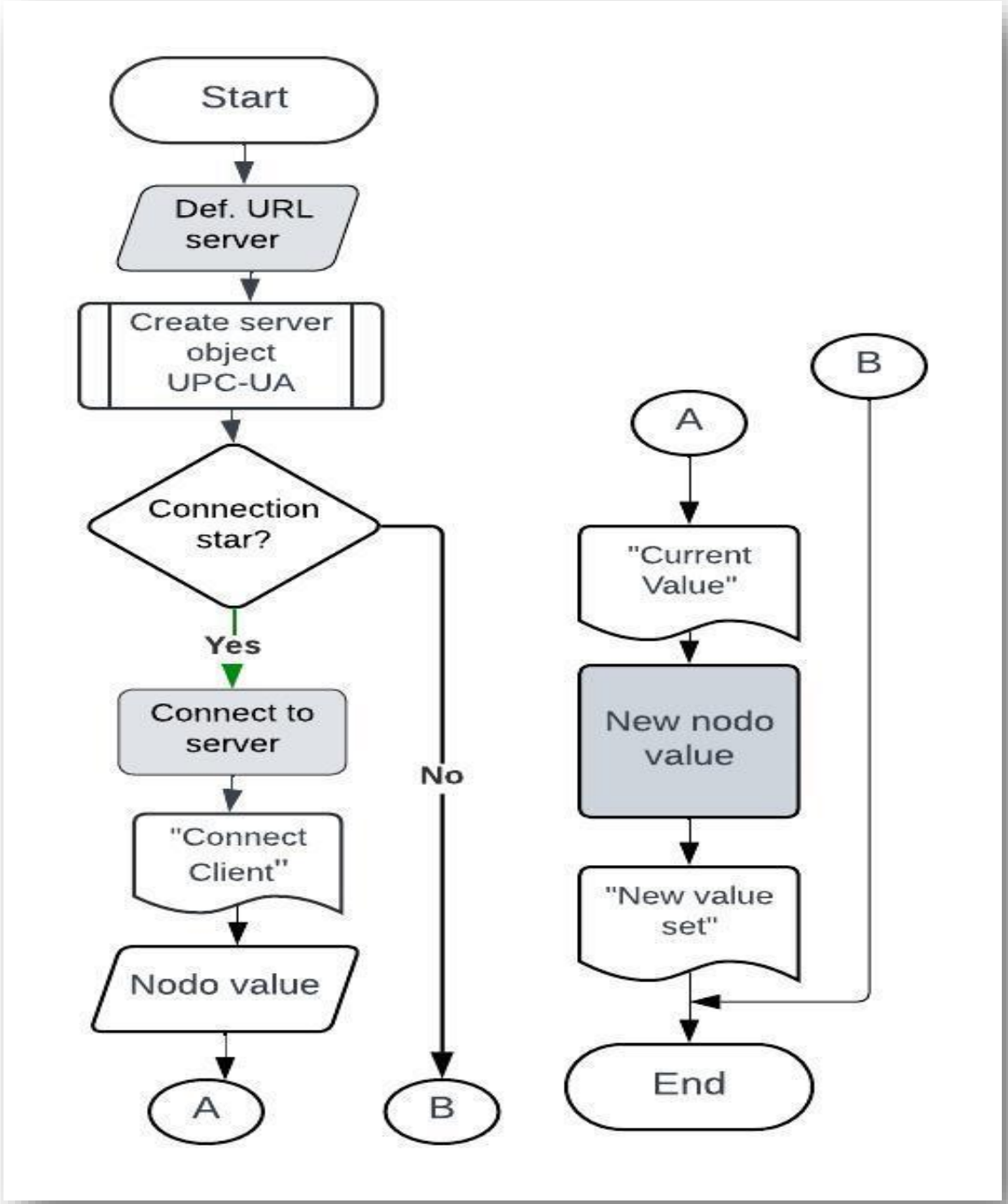
Introduction

- Control systems: Operation of feedback, open-loop and closed-loop control, and PID controllers.
- Industrial electronics: Basic principles of sensors, actuators, ladder diagrams, relays, and Boolean logic.
- Pneumatics and hydraulics: Fundamentals, components, and applications in automated systems.
- PLC programming: IEC 61131 languages, function block diagrams, and troubleshooting.
- Industrial networks: Communication protocols such as Ethernet/IP, Profibus, and Modbus.
- SCADA systems: Data acquisition, monitoring, and remote control of industrial processes.

Porposed System block diagram description



OPC-UA Client-server Flow Diagram



Cliente-Servidor OPC-UA

These mechanisms include authentication, authorization, and encryption.

OPC UA Client: Function: The OPC UA client acts as a data consumer.

It connects to the OPC UA server to read, write, or subscribe to the data exposed in the Address Space.

Reading: The client can request the current values of variables from the server.

Writing: The client can send commands to the server to modify the values of variables.

Subscription: The client can register to receive notifications from the server when the values of variables change.

Client-Server Connection: The client discovers available OPC UA servers on the network.

Connection: The client establishes a secure connection with the selected server.

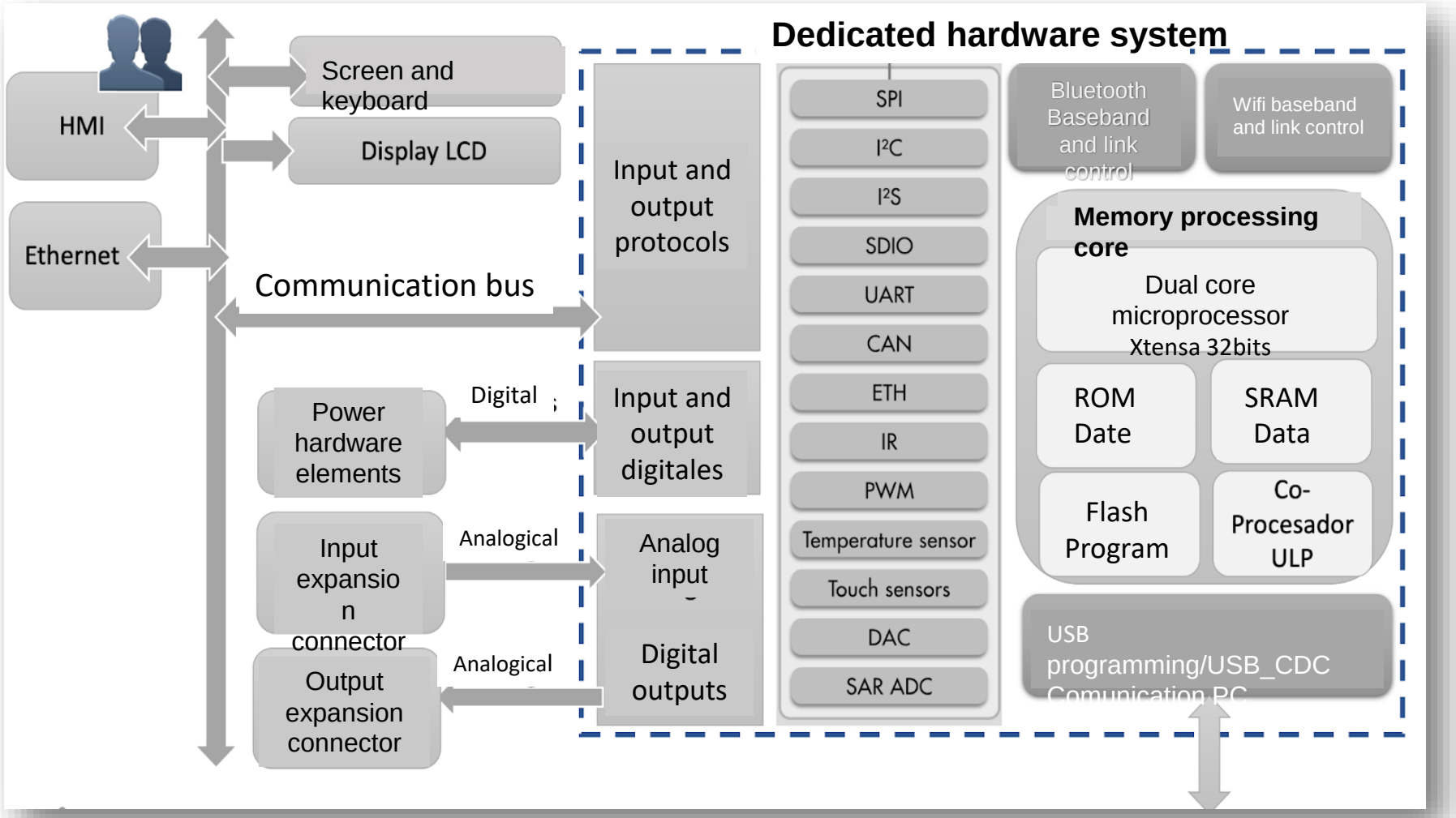
Authentication and Authorization: The client authenticates with the server and is granted permissions to access certain data.

Navigation: The client navigates through the server's AddressSpace to locate the nodes of interest.

Data Exchange: The client reads, writes, or subscribes to the data of the selected nodes.

Among the most prominent advantages of OPC-UA servers are their Interoperability, which allows communication between devices and systems from different manufacturers and platforms.

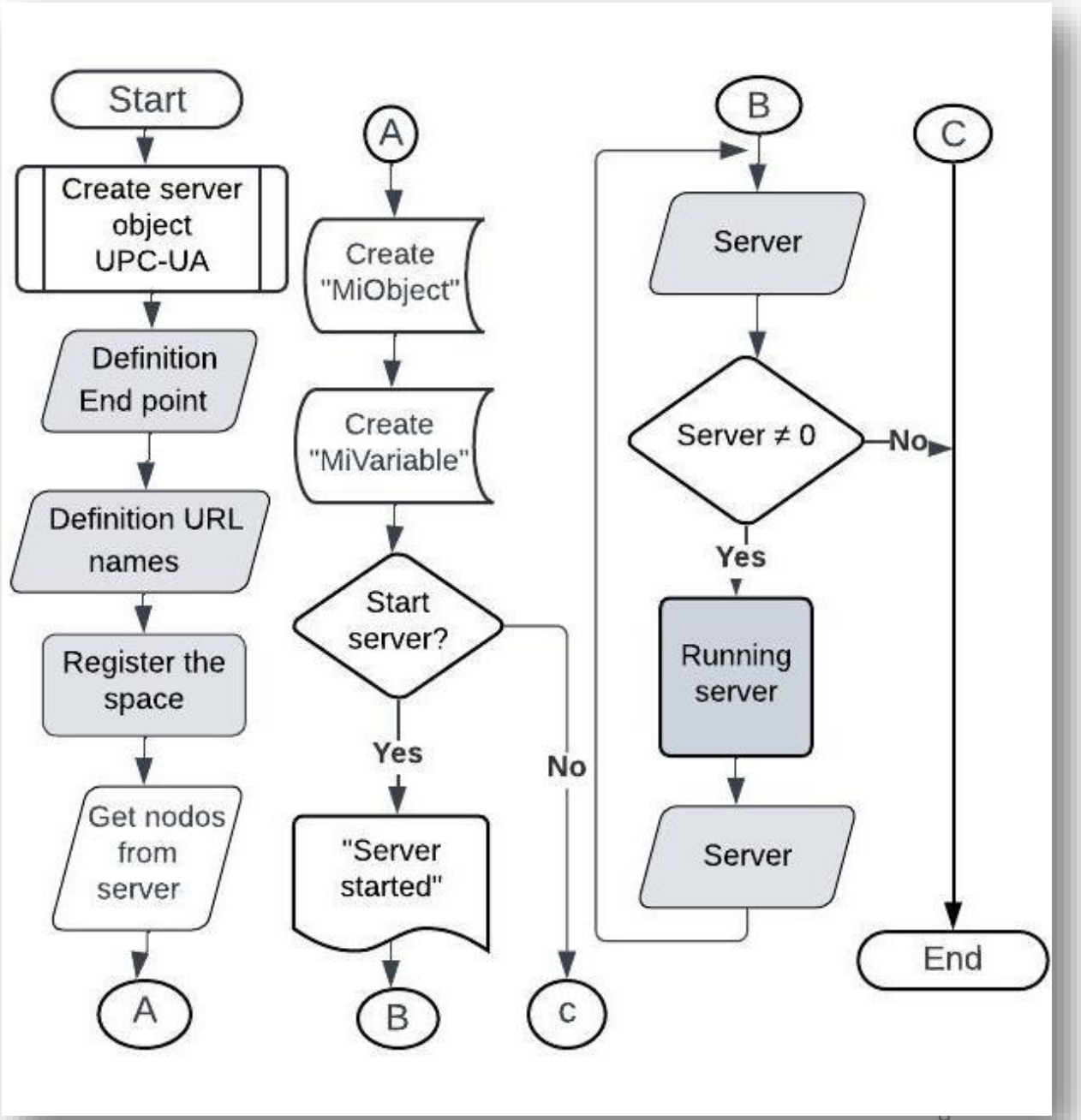
Description of the Hardware component for connection with the computer through OPC 191 libraries and the reading of physical inputs and outputs.



Flowchart of the Python code to implement a client to respond to OPC-server connectiones

OPC-UA Client –Server

An OPC-UA client in Python is used to connect to an existing OPC-UA server, navigate its data structure (node tree), and perform read and write operations on the variables or nodes exposed by the server.



Results

Standardized and secure communication: The use of OPC UA as a communication protocol allowed the establishment of a robust and secure data exchange channel between the ESP32 board and other 215 industrial control systems, ensuring interoperability and information protection.

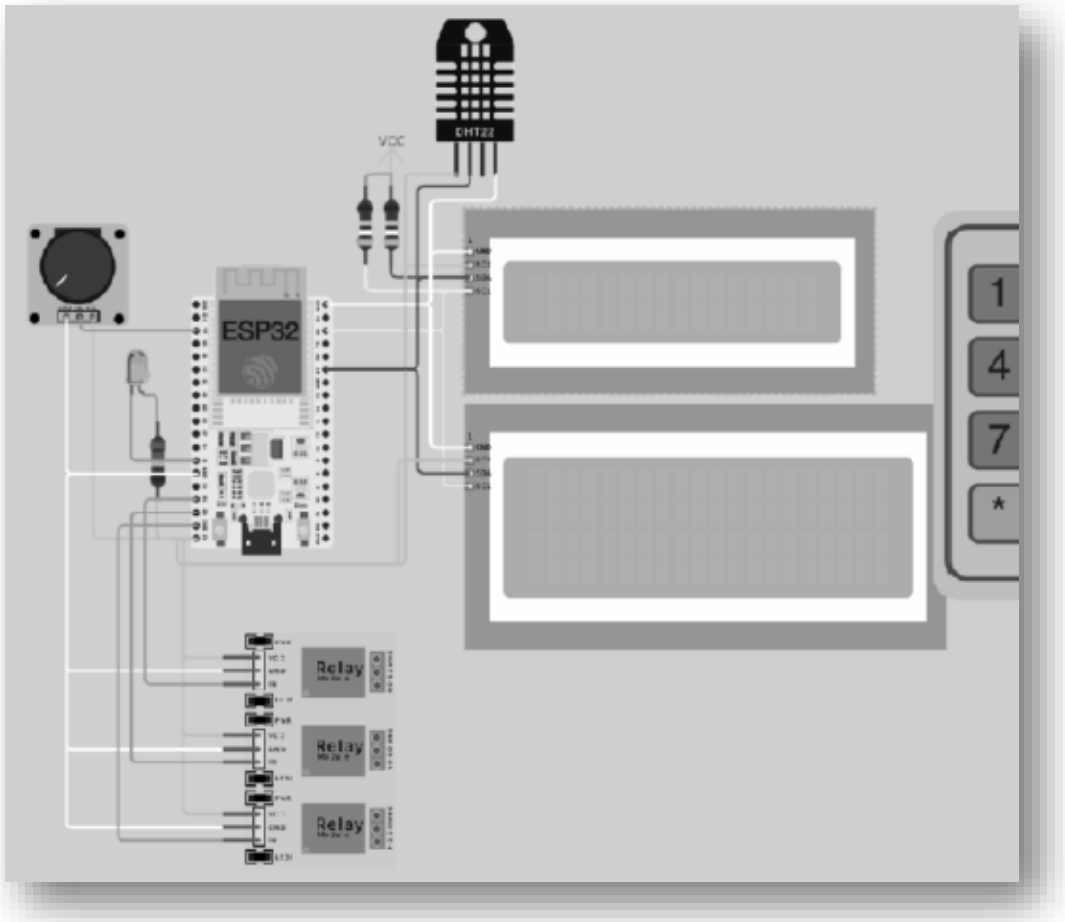
Real-time monitoring and control: The ability to read and write OPC UA variables from the ESP32 board enabled real-time monitoring of simulated parameters of the industrial device and remote control of its behavior, providing an interactive and dynamic experience.

Flexibility and scalability: The architecture of the OPC UA server on the ESP32 allowed easy adaptation to different types of simulated industrial devices, as well as the possibility of adding new variables and functionalities as project requirements evolve.

Results

Cost reduction: The use of the ESP32 board, a low-cost and widely available hardware platform, along with the implementation of open-source software for the OPC UA server, contributed to an economical and accessible solution for simulating industrial devices.

Integration with existing systems: The compatibility of the OPC UA server with various SCADA systems and industrial management platforms facilitated the integration of the ESP32 board into already established industrial environments, expanding monitoring and control capabilities without the need for major modifications to the existing infrastructure.



Schematic of the connections to the ESP32 to operate with power inputs and outputs.

Conclusions

Industrial automation has transformed production, but its teaching faces challenges. The ESP32, a low- cost microcontroller, offers an innovative solution for the practical teaching of industrial automation. Its compatibility with multiple communication protocols and user-friendly development environments makes it ideal for educational and research projects.

The incorporation of simulation software and the implementation of an ESP32-based OPC-UA server allows students to interact with automation systems in a safe and controlled manner. The combination of accessible hardware, simulation software, and communication protocols like OPC-UA offers a promising 256 approach to teaching industrial automation, preparing students for the challenges and opportunities of Industry 4.0.

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