ASEC 2025 Conference

The 6th International Electronic Conference on Applied Sciences

09–11 December 2025 | Online

MDPI

Monitoring Electrical Parameters of a Machine Using RAMI 4.0 Concepts

Heitor Lifsitch Nogueira da Silva, Fábio de Sousa Cardoso,
Israel Gondres Torné, Angilberto Muniz Ferreira Sobrinho

School of Technology, Amazonas State University, Manaus-AM, Brazil

INTRODUCTION & AIM

Electrical energy is the "engine" of the modern economy and a strategic asset for the industrial sector, where efficient management is vital for competitiveness. Monitoring, standardizing, and recording the historical usage of this resource are essential for informed decision-making. However, the main barrier in the Industry lies in legacy machines that lack intrinsic connectivity. These crucial pieces of equipment generate vital electrical data, but they remain "blind" and are disconnected from management systems.

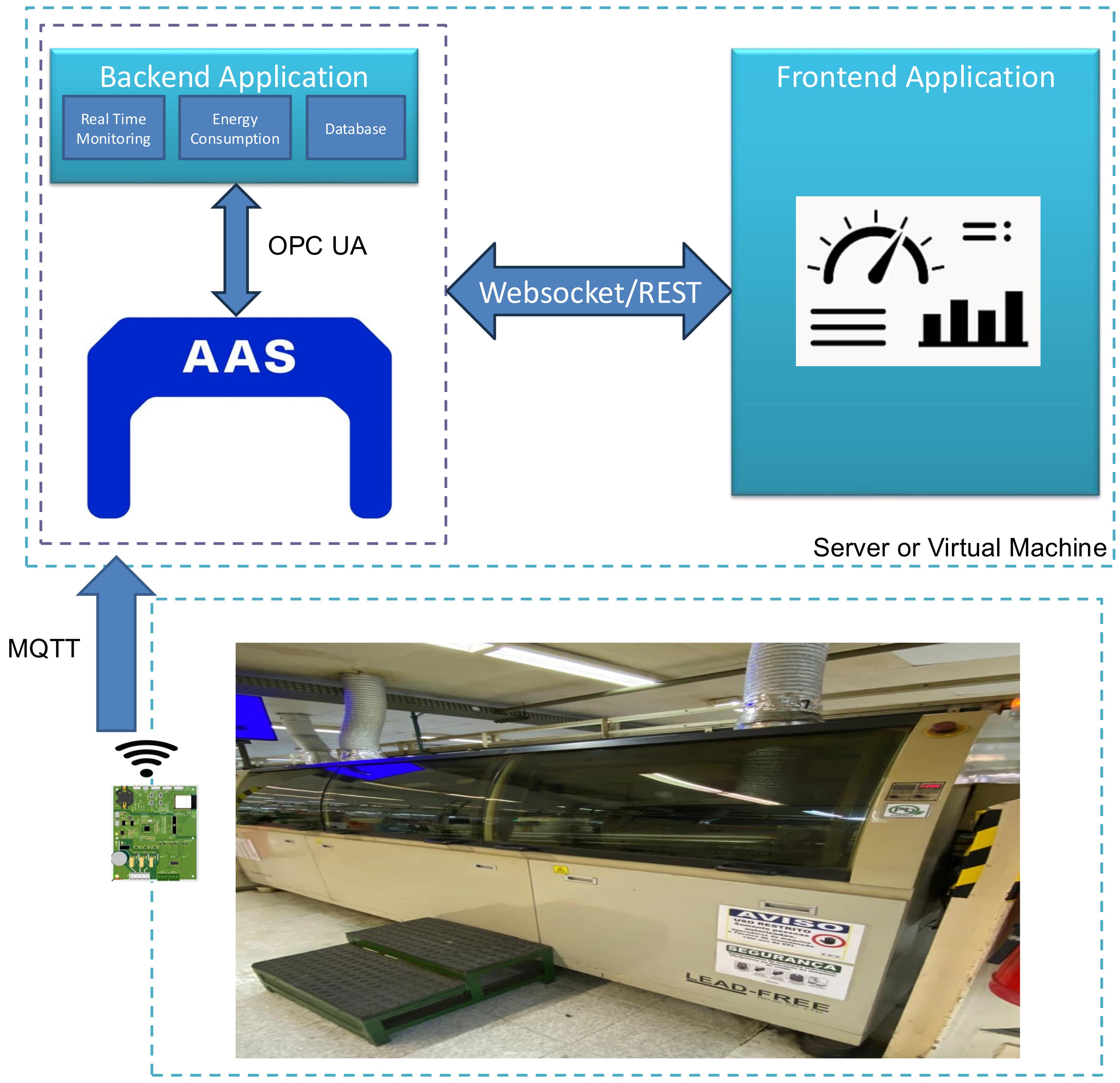
This work addresses this problem. We propose the development of a monitoring strategy based on the RAMI 4.0 framework to digitize the electrical parameters of non-connected machines. This transforms isolated data into strategic intelligence, enabling proactive maintenance and energy efficiency in assets that were previously out of the reach of digitalization.

METHOD

To address the lack of connectivity in legacy assets, the developed monitoring strategy is based on an Internet of Things (IoT) architecture. The acquisition of electrical parameters is performed at the edge by high-precision hardware, which combines the ADE9000 chip with an ESP32 microcontroller.

Efficient data communication to the management platform is ensured by the MQTT (Message Queuing Telemetry Transport) protocol. The monitored asset, an industrial welding machine, was digitized and modeled following the RAMI 4.0 principles. Its digital representation was structured as an Asset Administration Shell (AAS). The modeling and standardized definition of the AAS's submodels and properties were carried out using the Package Explorer software.

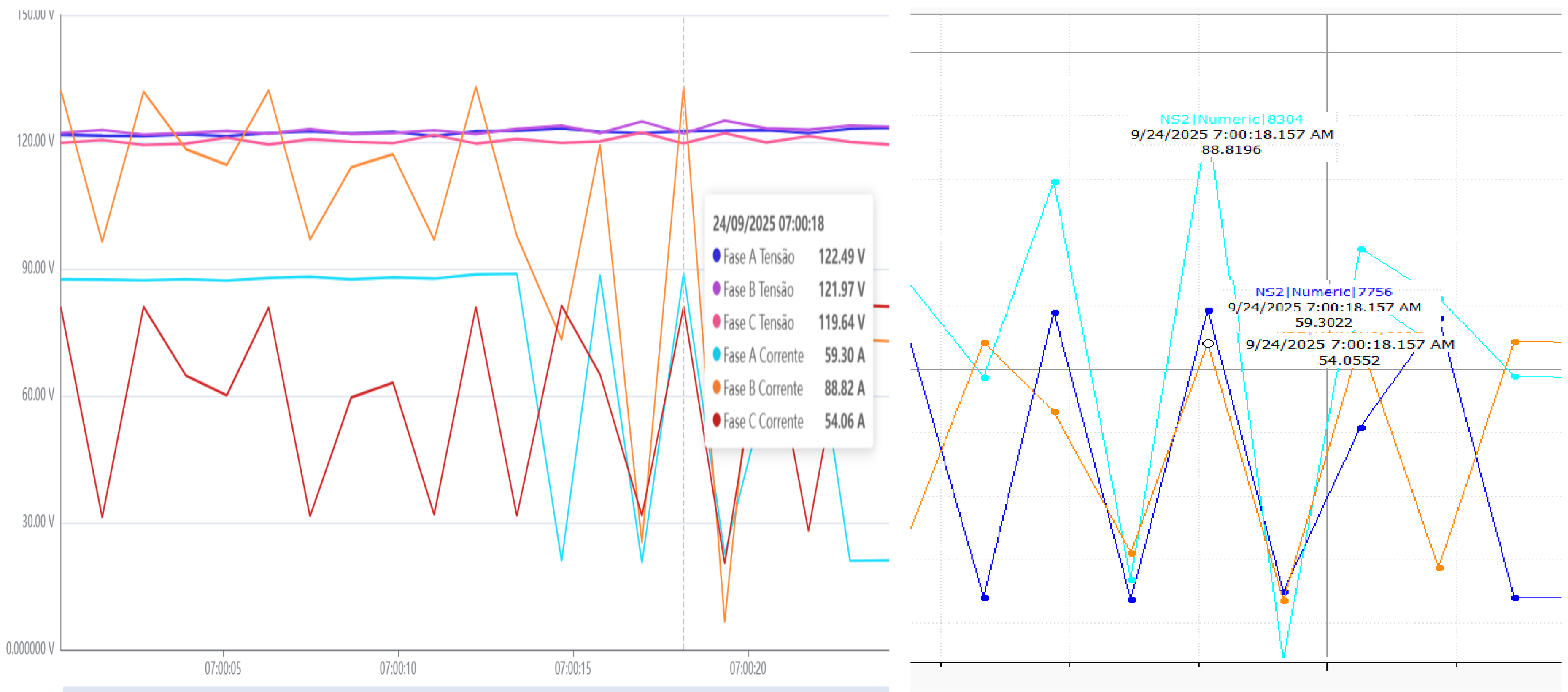
Additionally, the UaExpert software was employed as a visualization and testing client. UaExpert allowed for the validation of the AAS data structure and the verification of interoperability with the communication layer, confirming that the monitored and modeled data can be accessed by standard industrial management systems, such as OPC UA.



RESULTS & DISCUSSION

The developed system enabled the acquisition and visualization of three-phase voltage and current data from a legacy welding machine. The measurements were successfully transmitted via MQTT and displayed in real time on the IoT platform, confirming stable data acquisition and communication performance. The same parameters were made available through an OPC UA interface, allowing external tools such as UaExpert to access and validate the data structure defined by the Asset Administration Shell (AAS).

The observed voltage and current values demonstrated the correct operation of the ADE9000 sensor and the effectiveness of the ESP32 as an edge device. The system maintained consistent data sampling and transmission rates. These results show that the proposed integration achieves end-to-end connectivity and interoperability between the physical layer and the information layer in accordance with RAMI 4.0.



CONCLUSION

The proposed architecture proved to be effective for the digitalization of legacy industrial equipment by integrating IoT data acquisition, standardized modeling through the Asset Administration Shell, and interoperability by OPC UA. The system demonstrated stable operation in collecting and transmitting three-phase electrical parameters, providing a reliable data source for monitoring and analysis. This approach enables legacy machinery to become part of digital ecosystems aligned with RAMI 4.0, promoting energy efficiency and predictive maintenance without requiring modifications to existing equipment.

FUTURE WORK / REFERENCES

Future developments will focus on expanding the proposed architecture to include advanced analytics and fault diagnosis. Additionally, new submodels will be added to the AAS to represent maintenance indicators and energy efficiency KPIs. Further validation will also be conducted with other types of industrial equipment to assess scalability and interoperability in heterogeneous environment.