middleware approaches proposed by the research community. Finally, we demonstrated the proposed middleware's architecture and implementation. The main components of the system are the data processing and the request processing, each developed around a low-level ontology model. The ontology implemented in the middleware enables the automatic classification of each registered object based on its type and role, ensuring high performance and rapid response within the system. The data processing module is responsible for retrieving data received from the communication layer, updating the designed ontology, and transferring measurements to the data management layer for storage. The request-processing module implement a search engine to facilitate the determination of appropriate objects and sensors to respond to real-time incoming measurement requests from the decision layer. In future work, we plan to focus on designing and implementing the decision layer within the proposed middleware. This layer will enable the smart gateway to detect anomalies based on user habits and predefined thresholds, make decisions, and act through IoT system actuators. We will utilize technologies such as Machine Learning algorithms and semantic web technologies to analyze and process stored and real-time data, allowing us to define user habits and make the entire system smarter, more reliable, and efficient.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Mohammed Lamnaour carried out the software programming. Moundir Raiss, Yasser Mesmoudi and Yasser EL Khamlichi helped in the testing of the code components. Abderrahim Tahiri and Abdellah Touhafi conceived the original idea. All authors contributed to the design of the research and to the writing of the manuscript. All authors had approved the final version.

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