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Instituto Politécnico de Viana do Castelo
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Welcome

This document presents the proceedings of the 2nd Symposium of Applied Science for Young Researchers - SASYR. This scientific event welcomed works by junior researchers on any research topic covered by the following three research centres: ADiT-lab (from IPVC, Instituto Politécnico de Viana do Castelo), 2Ai (from IPCA, Instituto Politécnico do Cávado e do Ave) and CeDRI (from IPB, Instituto Politécnico de Bragança). The main objective of SASYR is to provide a friendly and relaxed environment for young researchers to present their work, discuss recent results and develop new ideas. In this way, this event offered an opportunity for the ADiT-lab, 2Ai, and CeDRI research communities to gather synergies and promote collaborations, thus improving the quality of their research. The SASYR 2022 took place in a hybrid environment at Escola Superior de Tecnologia e Gestão of Instituto Politécnico de Viana do Castelo on the 22nd of June, 2022.

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Table of Contents

Smart system for monitoring and controlling energy consumption by residence production and load

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Abstract. Monitoring and controlling the energy consumption of electrical appliances brings significant benefits to both consumers and the energy utility. This work presents a system for monitoring and controlling energy consumption by residence loads connected to smart plugs. The user will have a tool to view consumption information and remotely turn loads on and off, as well as control the power level at which certain appliances will operate. In addition, it is intended to give the system the ability to make decisions regarding the operation of electrical devices based on the electrical energy available. This decision-making can occur either through priorities established by the user or, possibly, through Machine Learning applied to the system, based on the consumption pattern. Solutions like these can even be applied in situations where the user produces his own energy and would like to use the surplus produced to meet certain loads.

Keywords: Monitoring and control Energy · Internet of Things · Priority of loads · ML.

1 Introduction

Currently, technological growth, coupled with the development of the Internet of Things (IoT), has fostered the evolution of smart systems [4, 10]. In this scenario, terms such as Smart City, and Smart Home, among others, are increasingly common. Within this theme, the Smart Plug technology can be highlighted, a device that, connected to residential electrical appliances, allows the monitoring of the energy consumption of these types of equipment as well as its remote control, including turning on and off [7]. The adoption of this technology interferes with the consumption pattern of its users. It can contribute to a more conscious use of energy [4].

Regarding the monitoring and control of plugs, several platforms can be used for such functions, such as applications on smartphones, through which the user can monitor their consumption and turn on/off the plug [1]. Thus, this work deals with a project under development that aims to monitor and control energy consumption in devices connected to smart plugs, allowing the user to visualize their consumption pattern and control their devices remotely from the activation and deactivation of the devices until the control of the consumed power. In addition, the smart monitoring and control system will have the ability to make decisions based on energy consumption priorities that the user can set. As an example, the consumer will be able to define the time when specific devices must be turned on or off. Alongside this process, Machine Learning will also be implemented for the system's decision-making, contributing to the energy consumption by the devices with the highest priority given the available energy, whatever the source, and the user's consumption pattern.

Thus, this work is organized in parts, so that, in topic 2, the related works to the project theme are presented; in topic 3, the research proposal aims to reaffirm the objective to be achieved with the development of the project; in topic 3.1, the work development in this scenario is presented and, in topic 4, future works and the conclusion of the exposed ideas are presented.

2 Related Works

Currently, monitoring energy consumption is vital for taking measures that lead to a more conscious use of energy, the reduction of the exacerbated use of energy resources, and the consequent development of energy efficiency. The reality that involves energy management and introducing the concept of the IoT in the energy sector, the evolution of smart systems is remarkable, both on the generation and distribution side and on the demand side. As an example, in [2], Abdulrahman Al-Ali et al. published a paper on an Energy Management System (EMS) for smart homes, in which they used IoT and a data analytics platform. In this context, the microcontroller collected data regarding energy consumption and environmental conditions and sent it to a server. Then, the information was stored in a database and analyzed using Business Intelligence (BI) tools so that it could later be organized in a visually understandable way. Tables and graphs define this format, and reports are presented to energy consumers through a mobile platform. The system also gave the user the ability to control home devices remotely. Basically, through the mobile application, the consumer could turn on/off devices, which were connected to relays commanded by the microcontroller.

In [5], Syed Zain Rahat Hussain et al. developed a load monitoring and control system using LoRa technology and a SCADA server. The project consisted of a load energy consumption measurement system, whose data were processed and sent to a gateway via LoRa. The information was sent to a SCADA server managed by the power utility from the gateway and using the MQTT communication protocol. This server had a data visualization interface and functions such as alarms, and report development, among others. The information was analyzed in real-time and the SCADA system allowed ON/OFF control of the loads.

In addition to this topic, in [10], Kaike Alves Silva developed a system for monitoring energy consumption by electrical loads. For this, specific loads were used from which electrical quantities were measured, such as active, reactive, and apparent power, effective current and voltage, and the power factor. The ESP32 microcontroller was used for data processing due to its wide applicability and relevant resources, such as Wi-Fi communication and connection to the Arduino IDE. From there, the information was sent to the InfluxDB database, a type of TSBD (*Time Series Database*) and open-source database, commonly used in applications that deal with real-time data. Grafana was used as a tool to visualize the measured quantities, which provides the user with a real-time view of the measurement system and histories and alerts.

Within the reality that involves energy management using priorities for the use of electrical appliances, in [9], Mohammad Shakeri et al. developed a work that proposes the use of smart plugs connected to a residential energy management system (HEMS), which, in turn, communicates with the utility through a smart meter. Smart plugs can store consumption parameters of electrical appliances and send this information to the HEMS controller. It controls electrical devices based on established consumption priorities, defined by the user when the devices are controllable. In addition, HEMS also receives signals from the utility company to change or reduce the operating time of certain electrical appliances according to energy demand and price.

3 Research Proposal

The objective of this work is to develop a system for monitoring and controlling the consumption of electric energy through smart plugs, giving the user the possibility to visualize information related to their consumption pattern and to define which loads will work, in addition to the power level at which certain loads will act. In addition, it is intended to insert priority strategies for the operation of loads and also to use analysis methods such as Machine Learning to define, in a more elaborate way, the behavior of the system. Such strategies will also be useful to shape the functioning of systems that aim to take advantage of surplus energy production, redirecting it to specific loads instead of supplying it to the utility. Next, what was developed in the project will be presented, and the functions that will still be implemented.

3.1 Work development

The data read by the plugs is processed by ESP32, a microcontroller that contains features like built-in WiFi and Bluetooth, as well as two processors and other features that make it widely used in many wireless applications [8]. ESP32 sends data over WiFi to an Message Queuing Telemetry Transport Protocol (MQTT) broker. This is a communication protocol intended for Machine-to-Machine (M2M) communication, and its use involves publishing and transmitting data using a broker [11]. Figure 1 presents the structure of the system under development.

The code that runs on ESP32 is developed in the Arduino IDE. In addition, through MQTT, the Node-RED control tool is used, an open-source platform designed from Node-Js, through which it is possible to create flows that perform functions such as connecting to web services and sending data for other platforms, for example, [6]. Then, the consumption data is sent to the InfluxDB database and presented by the Grafana platform. In this way, users can view the consumption of appliances connected to smart plugs through their monitoring and control devices.

4 Future work and conclusions

Still considering Figure 1, it is intended to develop in the system the ability of the user to control the smart plugs, either turning the electrical devices on or off or control the power level at which they will work, and the ability to determine the priority

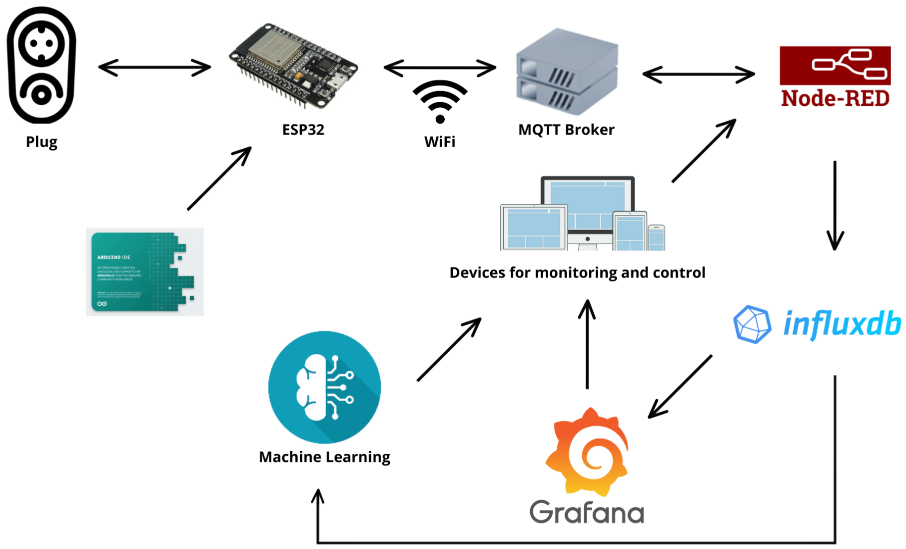

Fig. 1: Representation of the energy consumption monitoring and control system.

operation of their gadgets. In addition, the objective is to apply Machine Learning so that the system itself can analyze consumption behavior and make coherent decisions about which devices will work or not and under what conditions. As an example, in a scenario where the user generates his own energy and would like to use the surplus energy produced without sending it to a battery bank or to the grid, the consumer can manually establish a priority list of certain loads that will consume surplus energy and the power at which they will run, based on your needs. As defined by the user, a command is sent to the smart plug connected to the devices in question. When the smart plug executes the command established by the consumer, this information will be stored in a database, in InfluxDB itself. In this same context, decision making can also be done using Machine Learning. Based on the user's consumption history at a given time, excess energy will automatically be directed to specific loads. Likewise, when smart plugs execute the commands sent, this information will be stored in a database.

In short, it emphasizes the importance of working on the use of available electrical energy to meet the user's needs without compromising their comfort and consciousness.

References

1. Adiono, T., Fathany, M.Y., Feranti Anindya, S., Fuada, S., Purwanda, I.G.: Using a smart plug based on consumer electronics to support low power smart home. In: 2019 4th International Conference on Intelligent Green Building and Smart Grid (IGBSG). pp. 376–379 (2019). https://doi.org/10.1109/IGBSG.2019.8886272
2. Al-Ali, A., Zualkernan, I.A., Rashid, M., Gupta, R., Alikarar, M.: A smart home energy management system using iot and big data analytics approach. IEEE Transactions on Consumer Electronics **63**(4), 426–434 (2017). https://doi.org/10.1109/TCE.2017.015014
3. Brito, T., Zorawski, M., Mendes, J., Azevedo, B.F., Pereira, A.I., Lima, J., Costa, P.: Optimizing data transmission in a wireless sensor network based on lorawan protocol. In: Int. Conf. on Optimization, Learning Algorithms and Applications. pp. 281–293. Springer (2021)

4. Castro, R.C.C., Lunaria, M.A.R., Magsakay, E.d., Leyesa, M.C., Silao, N.E.G., Jaudian, J.G., Morsiquillo, E.J.: Intelliplugs: Iot-based smart plug for energy monitoring and control through wifi and gsm. In: 2020 IEEE 12th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM). pp. 1–4 (2020). https://doi.org/10.1109/HNICEM51456.2020.9400116
5. Hussain, S.Z.R., Osman, A., Moin, M.A., Memon, J.A.: Iot enabled real-time energy monitoring and control system. In: 2021 9th International Conference on Smart Grid (icSmartGrid). pp. 97–102 (2021). https://doi.org/10.1109/icSmartGrid52357.2021.9551208
6. Lekić, M., Gardašević, G.: Iot sensor integration to node-red platform. In: 2018 17th International Symposium INFOTEH-JAHORINA (INFOTEH). pp. 1–5 (2018). https://doi.org/10.1109/INFOTEH.2018.8345544
7. Mtshali, P., Khubia, F.: A smart home energy management system using smart plugs. In: 2019 Conference on Information Communications Technology and Society (ICTAS). pp. 1–5 (2019). https://doi.org/10.1109/ICTAS.2019.8703522
8. Pujaria, U., Prasenjeet Patilb, N.B., Asnodkard, M.: Internet of things based integrated smart home automation system. SSRN Electronic Journal (2020). https://doi.org/http://dx.doi.org/10.2139/ssrn.3645458
9. Shakeri, M., Amin, N., Pasupuleti, J., Mehbodniya, A., Asim, N., Tiong, S.K., Low, F.W., Yaw, C.T., Samsudin, N.A., Rokonuzzaman, M., Hen, C.K., Lai, C.W.: An autonomous home energy management system using dynamic priority strategy in conventional homes. Energies **13**(13) (2020). https://doi.org/10.3390/en13133312, `https://www.mdpi.com/1996-1073/13/13/3312`
10. Silva, K.A.: Monitor de consumo de energia elétrica com conexão à internet. `https://repositorio.ufu.br/handle/123456789/24832` (2018)
11. Songkittirote, N., Setthapun, W., Sintuya, H.: Smart plug control system development with mysql database and mqtt protocol. In: 2018 International Symposium on Computer, Consumer and Control (IS3C). pp. 76–79 (2018). https://doi.org/10.1109/IS3C.2018.00027
12. Zorawski, M., Brito, T., Castro, J., Castro, J.P., Castro, M., Lima, J.: An iot approach for animals tracking. In: Int. Conf. on Optimization, Learning Algorithms and Applications. pp. 269–280. Springer (2021)