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HOME ELECTRIC POWER MANAGEMENT MODEL: PRELIMINARY PROPOSAL

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ABSTRACT

A conceptual approach of a home energy management model is proposed, called GEDE (Home Electric Energy Management), which has as its primary purpose to contribute to home energy efficiency; The model involves communication protocols, infrastructure, and software as a management tool for making energy decisions related to the consumption or generation of electricity by the residential end-user

1. Introduction

The traditional elements of the electric energy value chain: generation, transmission, distribution, and consumer, make the latter only a service recipient without adding any added value to the system since the process is unidirectional. However, in the last decade, technological development at the residential level, which aims to improve the quality of life and increase user comfort, has led to an increase in electrical energy use. Opening the emergence of management systems energy systems in the home-HEMS (Home Energy Management System) makes possible the connection of domestic devices in a network for their remote management as a real-time saving system. Similarly, the incorporation of smart grids, which are an improvement in the electric power supply system's infrastructure, by allowing energy flows in a bidirectional manner through electric power. The value chain has created a new energy scenario concerning the end-user's participation in making energy decisions related to the consumption and generation of home electricity (renewable and non-renewable energy) (Kaushal et al., 2015).

Although in-home applications are more feasible to implement non-renewable sources, such as diesel generators or microturbines, the proposed system includes renewable sources, such as photovoltaic systems. Since they represent a clean energy alternative, they do not pose health risks, and their origins are inexhaustible. Further, its use affects awareness of environmental problems and contributions to its sustainability through its use by consumers. From now on, referred to as "active user" of the energy management process, GEDE enables the inclusion of renewable energies within residences and facilitates the interaction of information and communication technologies in the electric energy management process (Dwyer et al., 2016).

2. Conceptualization for A Home Electrical Energy Management Model Home

Energy management systems (HEMS) work in conjunction with smart grids and Advanced Metering Infrastructure (AMI) to use electrical energy in residences from energy efficiency principles. Figure 1 presents a summary of the most relevant characteristics of some home management systems related by the scientific literature between 1970 and 2014 (Khuntia, Rueda, et al., 2016), where 91% corresponds to infrastructure, 68% software, 43% communication, 38% relationship with end-user and 6% the influence of external variables in the models. These characteristics of the management systems are defined in sections 2.1 to 2.4. high dimensionality (due to the exact location, tracking is complicated) and unavoidable uncertainty (variance and error) (Mahmoudi, et al., 2016). The new generation of smart meters has information and communication technologies since they provide energy consumption readings and additional information on their use.

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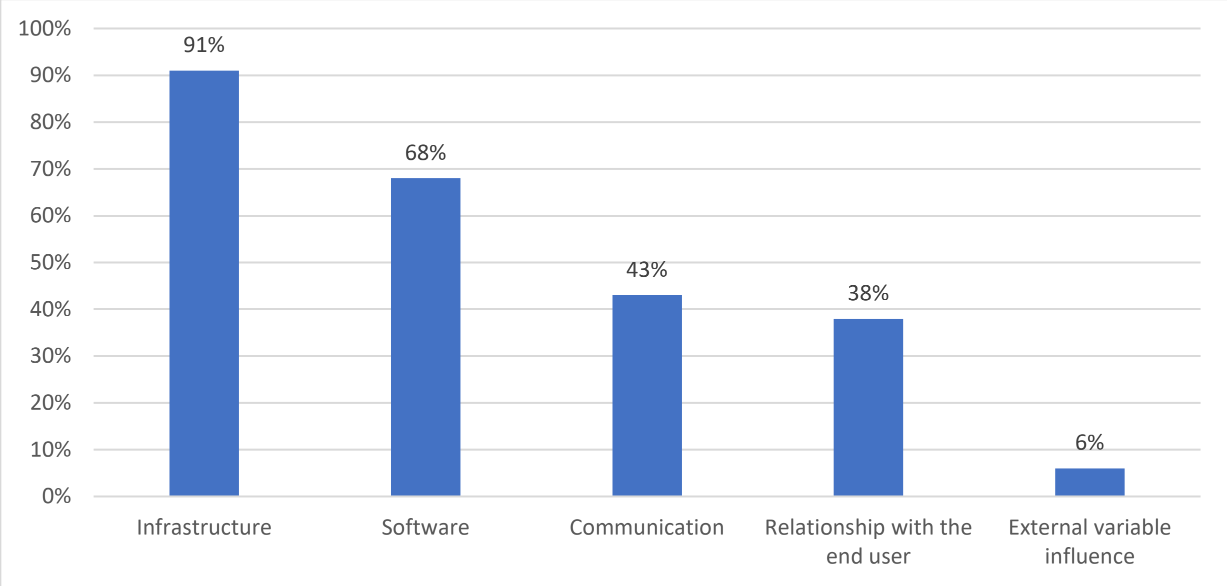

Figure 1: Characteristics of the management systems analyzed (1970-2014)

Approaches have been proposed to monitor a load of household appliances by different authors, such as: (Zhaoet al., 2016), who evidence an algorithm with rules based on pattern recognition, which requires at least one sensor per device. Özden-Schilling, (2016) develops a non-intrusive device (NALM) for load monitoring, characterizes the power signal in successive stages or events and relates to household appliances. Zahurul et al., (2016) present an algorithm based on pattern recognition for the total electricity consumption in a house, and they assume a constant device, which varies with the load and its configuration. Shen et al. (2016) show a load disaggregation algorithm that compares each change in the device's operating range with the total energy signal. On the other hand, (Geetha & Subramani, 2017) present indirect sensors to evaluate household appliances' energy consumption by measuring the variations in acoustic and magnetic fields when the appliances are turned on or off.

2.1. Infrastructure

Energy management systems are based on the monitoring, control and supervision of electrical variables such as current, voltage, frequency and phase, within an electrical installation; Some of the concepts involved in the infrastructure aspect are presented below.
Domestic: It refers to the automation and control of electrical and electrotechnical devices and systems centrally and remotely in the home. It is determined by an advanced measurement of the home electrical network infrastructure with a programmable smart meter and interconnected devices. Home automation provides energy management, security (Wu et al. 2017), well-being and communication services, all controlled by a central system for the home; its main objective is to improve residential users' quality of lives, providing automation in daily activities efficiently.

Monitoring instruments: The monitoring instruments are made up of sensors, signal adapters, measurement, and communication systems, making it possible to implement the monitoring system that is the foundation for supervision and control. The monitoring system is implemented with electronic devices with detection, calibration, self-test, decision making, communication or even a combination of them (Kagiri & Wainaina, 2017). These systems are supported by wireless sensor networks (WSN), which are spatially distributed networks with limited data collection, which control and manage information from intelligent services such as energy. However, there are drawbacks due to unpredictable movements, non-stationary design, ergonomic problems, communication, and those who are directly involved at the household level, and their interaction within the OSI (Open System Interconnection) model of communications.

2.2. Communication

Communication protocols are procedures used by home automation systems for communication between all devices connected to the network. The protocols can be of the type of open standard (free use for all), standard under license (open for all under license) or proprietary (exclusive use of the manufacturer or proprietary manufacturers) (Yaqoot, et al. 2016). Figure 2 shows the relationship of the protocols with the networks, reducing consumption at peak hours, facilitating the monitoring, supervision and control of electrical variables. In 1982, the Faculty of Engineering at the University of Florida developed an energy management optimization algorithm to reduce the cost of electricity by looking at the price structure and the time of use or demand, simulating electricity's needs through a computer. The electrical energy of a typical residence tests the efficiency of the algorithms. For the year 2003, a smart home called Grenoble experimental Smart home is proposed, whose model is based on a computer infrastructure framework with three layers: the application layer that offers monitoring services. The hardware layer with electrical devices and an intermediate layer allows the union

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between the two previous ones. Then, in 2013, iCHEMS was developed, which is a management system that is based on the prediction of renewable energy capacity, uses Zigbee technology with the IEEE802.15.4 standard, has an iCMS (intelligent management server in the cloud), an iPMD (Intelligent Power Monitoring of Devices), and iEMD (Intelligent Environmental Monitoring of Devices). In that same year, an Energy Management System based on the Rete algorithm was also presented (Yaqoot et al., 2016). The proposed system has smart connectors and sensors that connect to a LAN to communicate. The appliances are plugged into the smart connectors. Information from electrical devices and sensors is processed by algorithms based on IF-THEN rules.
The intelligent electrical management system (iEMS) was proposed in 2014. It comprised two parts: a fuzzy subsystem and an intelligent lookup table based on rules and fuzzy inputs that produce an output to the table.

Application	
Presentation	Active demand
	Future
Session	Future
Transportation	Future
Net	Local and Remote
Link	Measurement
Physical	Physical Devices in the home

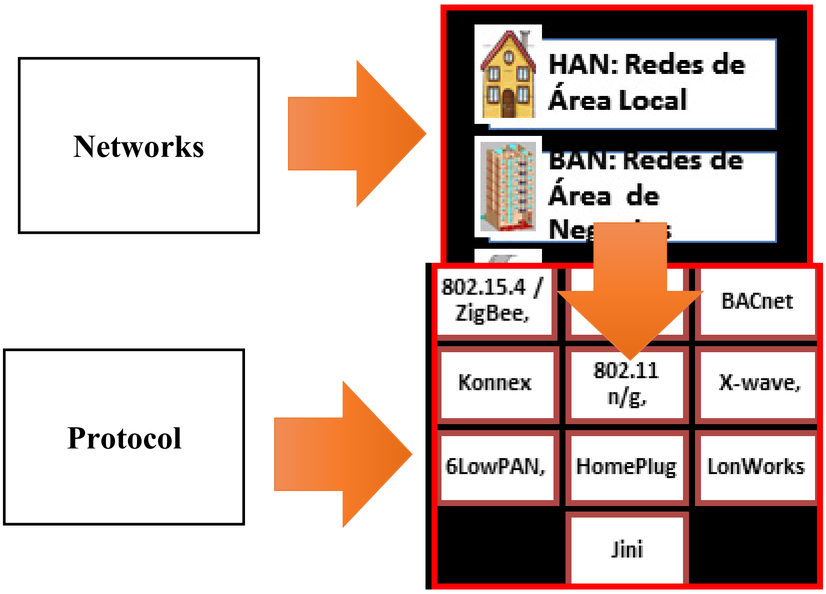

Figure 2: OSI model linked to home automation protocols

The intelligent electrical management system (iEMS) was proposed in 2014. It comprised two parts: a fuzzy subsystem and an intelligent lookup table based on rules and fuzzy inputs that produce an output to the table.

2.3. Software for monitoring, supervision and control of electrical variables

The implementation of hardware elements (smart plug, sensors) together with simple software algorithms for the intelligent search powered by inputs such as external sensors, external variables (price, battery storage, environmental conditions), and the behavior and preferences of the users. The second part corresponds to a new associative neural network model capable of assigning inputs to the desired outputs. The aim is to look for scenarios in different conditions to find the best energy efficiency and responsible demand by users, coinciding with their preferences and behaviours (Komiyama & Fujii, 2017). Similarly, others present a computational experiment that includes a residential energy consumption simulator, response mechanisms through optimization, a heuristic method, and a computing platform with regression techniques and optimization algorithms to observe the response. on request.

2.3. Elements transversal to the model

The influence of external variables, such as economic, social, political, environmental, and regulatory, affects the behaviour and habits of home energy consumption, which in turn are influenced by elements such as price, user comfort, awareness of environmental problems and trust in service companies. Changes in consumer behaviour using energy management systems properly can lead to energy savings, more efficient energy use and decisions that maximize energy generation with renewable sources (Tan, et al., 2015). Depending on how home electrical management systems are used, external variables directly impact, making it necessary to take them into account for more precise estimates in the models.

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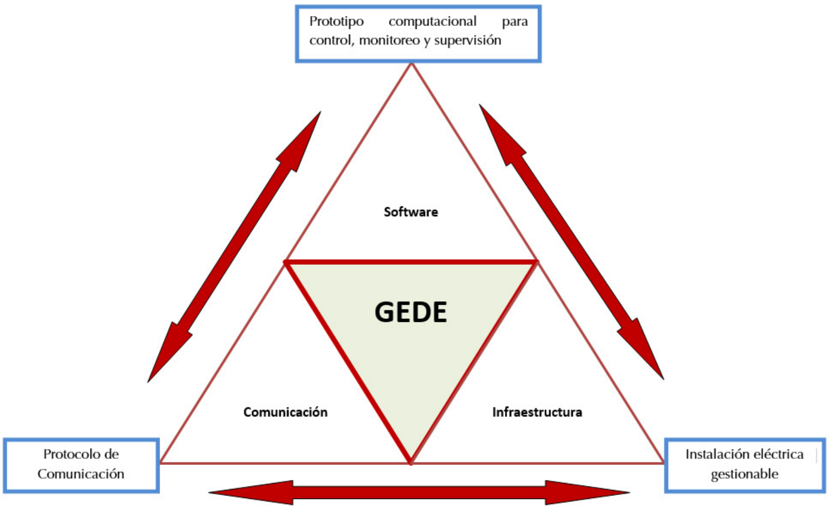

Figure 3: Schematic diagram of the management model

3. Approach to the Home Electrical Energy Management Model-Gede

3.1. Model architecture

Figure 3 shows the schematic diagram of GEDE, which has three modules: infrastructure, communications and software for monitoring, supervision, and control of electrical variables, which are explained below: Infrastructure module: in this module, there are the physical devices for communication, measurement, supervision, and control that will be part of the manageable electrical installation. The communications module comprises the different standard protocols implemented for communication between all devices and household electrical loads (Tagliaferri et al., 2016). Software module: where the management algorithms for monitoring, supervision and control of the electrical variables are located, according to the loads used by the users and the different power sources, it is the fundamental tool for decision-making.

- Power switch (I): makes the connection or disconnection of the load for protection purposes under the programming of the monitoring, supervision, and control system, using software algorithms.

3.2. Schematic diagram of the model

Figure 4 shows the block diagram of the operation of the GEDE home electricity management model. In this diagram, the elements of infrastructure and communications are related.

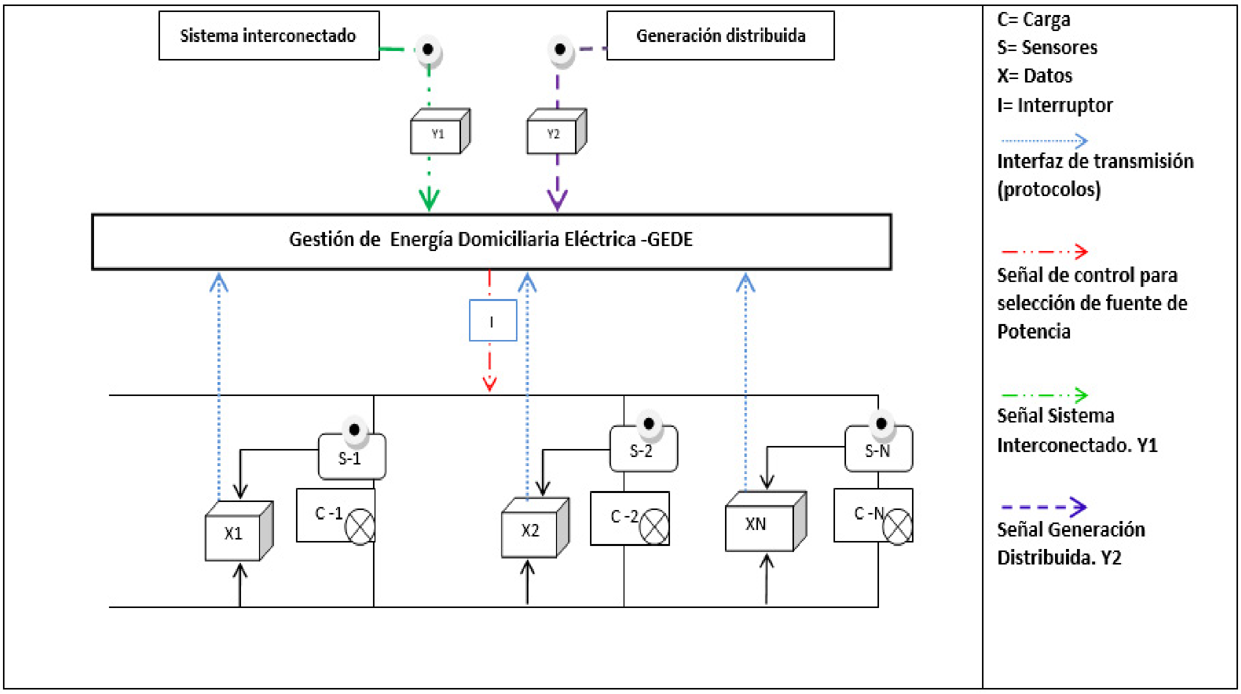

Figure 4: Block diagram of the operation of the GEDE model.

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The arrival of energy is visualized in two ways: from the interconnected energy system (Y1) or through distributed generation installed in the home (Y2), it is planned that these energy resources will be stored or consumed according to the intake of energy decisions of the user (Mbarek, et al. 2017). Other elements of the diagram in figure 4 are the following:

- Loads or devices (C): elements that require energy and are connected to the electrical installation and to be managed by the active user.
- Sensors (S): detect electrical variables converted into primary data such as system voltage and current devices (X).

The system is scalable, making it possible to add modules according to the number of elements to be managed. The information obtained by each of the modules is transmitted by the power line using the PLC protocol to the main GEDE module responsible for implementing the management algorithms to improve energy efficiency.
GEDE's main module monitors, supervises and controls both the load and the sources, thus making it possible to implement the necessary management algorithms following the operating parameters established in the system. The information obtained by each of the modules is based on the voltage and current measurements through each load or the source's supply. In such a way that always and in real-time, the status of the power delivered by the network and the Distributed Generation (DG) and energy consumed by parallel lines and in this way the electrical installation is used more efficiently (Rezzak & Boudjerda, 2017).

However, using WiFi, Bluetooth, Zigbee, X10 protocols or those referenced in figure 2 is not ruled out as a backup alternative, which will be established in later stages of the study, depending on the results obtained with this proposal. The voltage and current signals are sampled, quantized, and encoded to be processed by the autonomous GEDE processing system. The system allows the processing algorithms to establish the practical voltage and current values, which are transmitted through adjusted communications protocols to the OSI model (HTTP, TCP / IP, ETHERNET) to the main GEDE module.

All communication in this scenario is supported at the PLC protocol's physical level, using the same power line that feeds the devices. Currently, some devices facilitate communication with the PLC protocol inside homes, allowing high-bandwidth communications for Internet and television access (Sakah, et al. 2017). On the other hand, one of the autonomous systems is being carried out, where the voltage and current signals supplied through the communications network of the electrical installation are processed, both by the power supplies and by the electrical loads, to establish utilizing algorithms the best operating condition of the system. The central management system software will be implemented with high-level object-oriented languages and contemplates an object's development with real-time information on each autonomous system's status.

4. Approach to the Home Electric Energy Management Model-Gede

4.1. Model architecture

Figure 3 presents the schematic diagram of GEDE, which has three modules: infrastructure, communications and software for monitoring, supervision, and control of electrical variables, which are explained below: Infrastructure module: in this module are the physical devices for communication, measurement, leadership, and management that will be part of the manageable electrical installation. The communications module comprises the different standard protocols implemented for communication between all devices and household electrical loads. Software module: where the management algorithms for monitoring, supervision and control of the electrical variables are located, according to the loads used by the users and the different power sources, it is the fundamental tool for decision-making.
• Power switch (I): makes the connection or disconnection of the load for protection purposes according to the programming of the monitoring, supervision, and control system, using software algorithms

4.2. Infrastructure aspects

The proposed management model incorporates the essential electrical devices at the source, and load level for the system tests monitored, supervised, and controlled, with the autonomous GEDE module. Each of GEDE's independent IP (Internet Protocol) modules consists of five fundamental components (figure 5): measurement system, autonomous processing system, control and protection system, TCP / IP communication system (communication control protocol). transmission) and PLC modem (Power Line Communication, for its acronym in English), making it possible to use the electrical installation infrastructure for communications between the devices that comprise it and the energy management system. The loads and determining the energy both consumed and delivered by the sources (Sakah et al., 2017). The method with the infrastructure shown allows better use of DG sources, such as incorporating them at peak hours and disconnect part of the load or all the interconnected system, depending on the energy efficiency scenario you want to manage.

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4.3. Communication aspects

The interaction model between the communications system and the infrastructure, shown in figure 6, uses the power line as the basis for communications, eliminating alternate cabling or methods for data transport. On the other hand, it has been selected as the primary protocol for PLC communications. It does not require an additional power system and implements wireless or wired network research to reduce the BER (Bit Error Rate Performance, for its acronym in English). Evaluating the PLC's performance through probability functions observing the behaviour of the error rate of the binary signal modulated by the transmission channels, which makes foresee that this technology will acquire more excellent reliability in-home systems (Quaschning, 2016). Communications are controlled by the software implemented by each of the autonomous IP modules, which incorporate an HTTP web server, forming a communications infrastructure between servers (each independent device includes an IP server).

4.4. Software aspects

The system software has two main components: 1) The GEDE IP autonomous system software, which implements a web server, the measurement, supervision, and control algorithms for the element it is managing, along with the communications system with the system. main GEDE and, 2) The primary management system of the GEDE, shown in figure 7, using a class diagram, integrates the information of each.

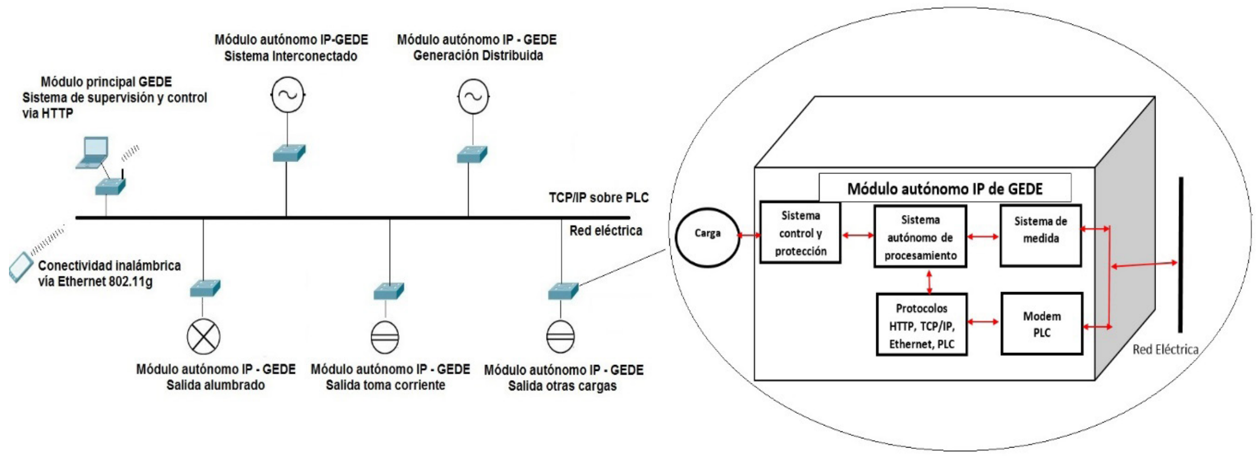

Figure 5: Deployment diagram with communication protocols for GEDE

5. Conclusion

This proposed energy management model allows taking advantage of the integration of technological advances in the same environment using infrastructure, software, and communications, to make better use of energy in residence and explore new opportunities that propose improvements in various aspects of sector regulations, with programs to use distributed generation from homes from renewable sources.

A new type of home installation is proposed that allows switching electrical circuits automatically to find the best system configuration to power the loads, integrating renewable sources to contribute to energy efficiency and taking advantage of the energy tariff system by the regulatory framework of each region. The system is scalable, making it possible to add modules according to the number of elements to be managed. The information obtained by each of the modules is transmitted by the power line using the PLC protocol to the main GEDE module responsible for implementing the management algorithms to improve energy efficiency. GEDE's main module monitors, supervises and controls both the load and the sources, thus making it possible to implement the necessary management algorithms under the operating parameters established in the system. The information obtained by each of the modules is based on the voltage and current measurements through each load supplied by the sources. In such a way, always and in real-time, the status of the power delivered by the network and Distributed Generation (DG) and energy consumed by parallel and in this way the electrical installation is used more efficiently. However, using WiFi, Bluetooth, Zigbee, X10 protocols or those referenced in figure 2 is not ruled out as a backup alternative, which will be established in later stages of the study, depending on the results obtained with this proposal. The voltage and current signals are sampled, quantized, and encoded to be processed by the autonomous GEDE processing system, which allows through the processing algorithms to establish the practical values of voltage and current, which are transmitted through adjusted communications protocols to the OSI model (HTTP, TCP / IP, ETHERNET) to the main GEDE module. All communication in this scenario is supported at the PLC protocol's physical level, using the same power line that feeds the devices.

Currently, some devices facilitate communication with the PLC protocol inside homes, allowing high-bandwidth communications for Internet and television access. On the other hand, they are one of the autonomous systems. The voltage and current signals supplied through the electrical installation's communications network are processed, both by the power supplies and by the electrical loads, to establish, through algorithms, the best operating condition of the system.

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The leading management system software will be implemented with high-level object-oriented languages and contemplates an object's development with real-time information on each autonomous system's status. For the management of the system, it is intended to implement software in the web application, which operates on computers and mobile devices, making it possible to acquire and store primary data such as voltage and current to determine power and energy, to establish the system efficiency.

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