Review of Research Paper: LoBEMS—IoT for Building and Energy Management Systems

IoT-CIA-1(KARTHICK.N.G)

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1 Introduction

In this review, I will discuss the research paper titled "LoBEMS—IoT for Building and Energy Management Systems" by Bruno Mataloto, Joao C. Ferreira, and Nuno Cruz. The paper was published in **Instituto Universitário de Lisboa (ISCTE-IUL), ISTAR-IUL, 1649-026 Lisboa, Portugal(MDPI)** in **2019**. The research paper presents a novel approach for building and energy management systems using IoT technology. The paper focus on the importance of the energy consumption in buildings, which represents 40% of total energy consumption. The authors propose the use of a Local Building Energy Management System (LoBEMS) to improve energy efficiency and reduce costs in buildings. The LoBEMS is based on the use of low-cost sensors and IoT principles, and it is cheaper than traditional Building and Energy Management Systems. The authors also propose the use of LoRaWAN (LoRa Wide Area Network) as a communication protocol for the LoBEMS, which is available in 140 countries and has low power consumption.

1.1 Background and Significance

The research paper aims to optimize energy consumption in buildings by utilizing the latest trends in IoT component, system, and platform integration through a layered architecture. The LoBEMS platform was designed with the goal of providing a common platform that would integrate multiple vendor-locked systems together with custom sensor devices, thereby providing critical data to improve overall building efficiency.

The energy savings were achieved by implementing a ruleset that controlled the already installed air conditioning and lighting control systems. This approach was validated in a kindergarten school over a three-year period, resulting in a publicly available dataset that is useful for future and related research. The sensors that feed environmental data to the custom energy management system are composed of a set of battery-operated sensors tied to a System on Chip with a LoRa communication interface. These sensors acquire environmental data such as temperature, humidity, luminosity, air quality, and motion. An already existing energy monitoring solution was also integrated.

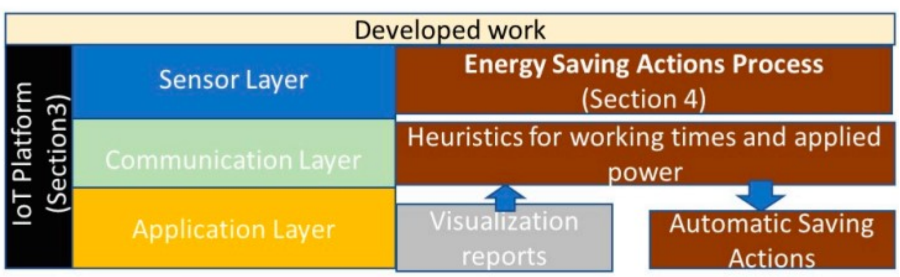
This flexible approach can easily be deployed to any building facility, including buildings with existing solutions, without requiring any remote automation facilities. The platform includes data visualization templates that create an overall dashboard, allowing management to identify actions that lead to savings using a set of pre-defined actions or even a manual mode if desired. The integration of the multiple systems (air-conditioning, lighting, and energy monitoring) is a key differentiator of the proposed solution, especially when the top energy consumers for modern buildings are cooling and heating systems.

As a result, the evaluation of the proposed platform resulted in a 20% energy saving based on these combined energy-saving actions. The study highlights the potential for IoT-based building and energy management systems to significantly reduce energy consumption and costs in buildings, and improve overall energy efficiency. It concludes that the implementation of LoBEMS can lead to not only cost savings but also environmental benefits and improvement of the quality of life.

2 Internet of Things Platform

The platform is designed to be a common platform for multiple devices and uses IoT-related technologies for data transmission.

The proposed system is structured in three layers: **the physical layer** with the sensors and actuators, **the network layer** with all the IP and LoRa communications, and **the application layer** where all the data is fused, processed, and displayed. The system allows for the manipulation of data in pre-defined templates and the creation of reports that allow users to extract heuristics for identifying energy savings. The system can be programmed to work automatically using pre-defined rules and can perform remote interaction with local A/C using infrared or through the OpenADR standard.



The authors highlight that the platform can be deployed to any building in any place and the major requirements are: the need for a local person to manage the place with the ability to use graphics configuration templates, energy monitor process with current transformers (CT) sensors need space at switchboards or there is a need to perform installation changes, installation of the sensors, Lora communication, and heating/cooling system remote interaction.

2.1 Physical Layer

In this section, the authors describe the physical layer of the LoBEMS system which consists of a developed board with four different types of sensors: temperature/humidity with a DHT22 sensor, light with a photoresistor sensor, motion with a Passive infrared (PIR) sensor and air quality with a MQ-135 sensor. The sensors are connected to a System on Chip (SoC) powered by a Lithium Polymer battery with a capacity of 2400 mAh and a small solar panel to restore its power over time. The sensors are configured to send data every 5 minutes.

The hardware equipment was chosen based on the following principles:

- Assembly flexibility - how easy it is to assemble from off-the-shelf components
- Accuracy and Versatility - how the sensors perform and what is their form factor
- Price - Low cost
- Modularity - Compatibility with other hardware ecosystems
- Power - Low/optimized consumption devices

The authors mention that the LoRa board that they used costs €13 and each sensor costs €2 on average. Comparing with commercial solutions, their developed board has a much lower cost. The LoRa board is fully programmable and customizable, and the platform is able to send all the necessary information over the LoRa network and access it from multiple applications. The authors also mention the low power consumption of the LoRa board and how it can be optimized by reducing the size of the messages sent by the board, and increasing periodicity to 10 min which also doubles the battery duration.

2.2 Network Layer

The LoBEMS system uses three wireless communication protocols:

- LoRaWAN
- WiFi
- IR.

LoRaWAN is used to establish a connection between Class A sensors and the LoRa gateway running on a Raspberry Pi. The authors are members of the LoRa Alliance and are using The Things Network (TTN) to develop an open access and secure IoT network based on LoRa technology. LoRaWAN supports an extremely low data rate but is suitable for IoT devices as sensors do not require very low latency or high-frequency transmissions.

WiFi is used to connect all other devices, actuators, and energy monitoring systems to the Raspberry Pi, where HTTP requests are originated to change device states. IFTTT is used to remotely control devices that require interaction with their API such as WiFi switches and power sockets, and all notifications are also sent using IFTTT email services

2.3 Application Layer

The third layer of the LoBEMS system includes the use of a Raspberry Pi to run services and applications, such as Node-RED and Maria-DB. Node-RED is an open-source software that is used to connect APIs, physical devices, other network interfaces and web services. It allows for the programming of rules in JavaScript to run or prevent specific flows and also connects to a local MySQL database where all the data is stored, such as temperature, humidity, light, motion, air quality values and other variables for each classroom. These stored data can be extracted at a later stage for analysis and reporting purposes.

3 Conclusion

In conclusion, this work presents the efforts on optimizing energy consumption by deploying an energy management system using the current IoT component/system/platform integration trends through a layered architecture. The proposed solution is a flexible approach that can easily be deployed to any building facility, including buildings with existing solutions, without requiring any remote automation facilities. The platform includes data visualization templates that create an overall dashboard, allowing management to identify actions that lead to savings using a set of pre-defined actions or even a manual mode if desired.

While this research presents a promising solution for improving building energy efficiency

3.1 Limitations

There are some limitations to consider such as the need for a local person that manages the place with the ability to use graphics configuration templates and from this customize data representation identify savings rules, Energy monitor process with Current transformers (CT) sensors need space at switchboards or there is a need to perform installation changes. Future research can explore these limitations and find ways to overcome them.

3.2 Future Works

The authors suggest that future work could include a prediction process and data presentation to influence users towards pre-defined saving goals or energy standards, and that this approach could also be applied to shared spaces with local interaction for non-administrative users. Additionally, user interface and user experience research may be necessary to influence behaviors.

Overall, this study provides a valuable contribution to the field of IoT and energy I recommend this paper to anyone interested in IoT applications in building and energy management.

Link to my research paper