A self-adaptive IoT architecture to support computational resource allocation in an e-health environment Extended Abstract – CTDSI/2025

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Abstract. *Intelligent environments are complex interaction spaces between people, sensors, devices, and systems. Software Engineering must tackle the intrinsic characteristics of devices and sensors and complex interactions in intelligent environments to consolidate development practices. This work aims to present a self-adaptive IoT architecture in an intelligent environment and evaluate an information system developed based on the architecture. The proposal concerns how the architecture modules work to develop new information systems. The work was developed through a real-world case study in an intelligent e-health environment. The results showed how a self-adaptive architecture using artificial intelligence can support the development of an information system to manage intelligent e-health spaces.*

1. Introduction

The Internet of Things (IoT) has consolidated in people's daily lives. The population commonly frequents intelligent environments where IoT sensors and devices are available [Fetahu et al. 2022]. Such devices and sensors assist and support the management and operation of these environments. The large-scale use of IoT has brought several complexities to the development of information systems. Software development teams have encountered various challenges when creating these systems [Amershi et al. 2019]. Substantial issues include managing distributed devices and sensors, dealing with heterogeneous configurations of behavior, and ensuring integration and interoperability with other sensors and information systems integration and interoperability with other sensors and information systems [Motta et al. 2018].

Software engineers seek to understand how the different elements available in intelligent environments interact, communicate, and behave. These items are the subject of study to provide techniques and methods to assist in developing information systems and applications for society in different contexts [Gupta et al. 2021]. An intelligent environment that has complex characteristics is e-health. These environments have sensors and devices that deal with people's lives and can directly influence an individual's well-being [Zadtootaghaj et al. 2019].

To deal with the complexities of an intelligent environment, data generated by IoT devices and sensors can be used by systems that manage the physical environment to adapt their operation to situations that occur in space. This characteristic is related to self-adaptation, which can occur due to the needs of the environment, the user, or the system's requirements. One of the uses of self-adaptive architecture aims to support the

different interactions in a complex and intelligent environment. In a scenario in which intelligent environments change people's daily lives, in addition to the rise of large-scale use of IoT devices and sensors, the need for architectural proposals for systems that deal with these complexities becomes even more evident [Weyns, 2020].

Based on the challenges presented and the opportunity highlighted using self-adaptive software architecture. This research addresses the construction of IoT architecture for intelligent environments, with the support of Artificial Intelligence (AI), enabling the development of information systems that can adapt computational resources to the environment's needs. A case study was conducted in a corporate intelligent environment to evaluate the architecture. We developed an information system using the architecture, demonstrating the interactions between people, devices, sensors, the environment, and the computational resources for each scenario.

2. Research methodology

Based on the contextualization of the work provided in the introduction, the main research question was formulated: **"How have computational resources been used in intelligent e-health environments that use IoT to develop architectures?".** We followed some steps to answer the research question:

(1) A systematic literature mapping was carried out to understand the state of the art, the practices adopted, and related works. The systematic mapping results established the following conjecture: **"Suppose we propose a self-adaptive architecture for developing IoT applications in e-health. In this case, can we improve the use of computational resources by systems, supporting data collection from intelligent e-health environments and supporting the management of these spaces?"**.

(2) After the systematic mapping and in possession of its result, the research question, and the conjecture, an exploratory study was executed [Gonçalo do Nascimento et al. 2021]. The exploratory study validated the difficulties related to intelligent environments, IoT, computational resources, information systems development, and the quality attributes intrinsic to IoT architectures in e-health environments.

(3) The Design Science Research (DSR) methodology was applied and allows information systems construction with well-established steps and establishes methods for constructing, evaluating, and generating scientific knowledge [Hevner et al., 2010]. Two DSR cycles were executed to answer the research question and validate the conjecture. Artifacts were developed and evaluated, and results were generated through the architecture development and two case studies [Gonçalo do Nascimento et al. 2023] [Gonçalo do Nascimento et al. 2024].

3. Main results and contributions

Through the research methodology presented, the work answered the research question and evaluated the results against the established conjecture. Based on the presentation of concepts related to IoT, intelligent environments, computational resources, and software development challenges, a systematic mapping was conducted to identify improvements, challenges, and opportunities in the literature. The challenges showed that computational resources, large-scale data processing, quality attributes, and artificial intelligence could be used in IoT architectures in intelligent e-health

environments. Furthermore, together, these concepts could support the development of information systems. In possession of the systematic mapping conjecture, an exploratory study was executed. During the exploratory study, an IoT architecture was proposed, and an information system was developed to support the management of the spread of the COVID-19 disease. The results of the exploratory study demonstrated how the information system was constructed using the architecture and helped us to gain knowledge about how IoT architectures and information systems work. Based on the exploratory study results, the stated hypotheses were evaluated. However, the study raised new challenges and complexities and strengthened the conjecture.

During the DSR phase, two cycles were executed. In this phase, two study cases were conducted to construct information systems using IoT architectures for intelligent e-health environments. The case studies were conducted within an intelligent medical clinic. The architecture developed in the DSR first cycle deals with IoT, large-scale data processing, and quality attributes. However, the first architecture did not deal with aspects directly related to computational resources and artificial intelligence, unlike the second architecture, which supported these themes. As a result, as the study evolved, both architectures addressed quality attributes and functional requirements. Finally, with the case studies carried out and the results of the DSR cycles, we were able to support the development of IoT applications that use e-health, optimizing the use of computational resources, through artificial intelligence.

As contributions to this work to the Information Systems, we can cite the proposed architecture and the process of developing IoT applications (exploratory study and two case studies). The final architecture contributes to the scientific community through the knowledge generated and provides solutions that can be employed. Development of an artificial intelligence module to adequately use computational resources by application architectures for IoT and intelligent environments. This contribution highlights the advantages, issues, and challenges associated with this technology. In addition to the benefits presented, optimizing computing resources allows organizations to avoid wasting funds on operating systems. It also ensures the optimization of the use of electrical energy, promoting sustainability. This aspect is particularly important when allocating computing resources based on application demands and their need for an intelligent environment.

In the context of the Grand Challenges for Research in Information Systems in Brazil from 2016 to 2026 and the challenges for implementing smart city concepts, this paper addresses the unprecedented need to present how IoT, cloud, edge, and fog computing technologies have enabled the development of an information system for an intelligent environment, such as an intelligent medical clinic. The information system was designed based on a self-adaptive architecture that selects computational resources effectively and ensures their efficient use. This efficiency encompasses the interactions between various agents, including people and technological devices, and aims to prevent the excessive consumption of resources, ultimately leading to enhanced efficiency in energy and computational resource usage.

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