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PRODUCT TRACEABILITY IN THE INTERNET OF THINGS CONTEXT

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KEYWORDS: product recall, product traceability, non-conformity alert, Internet of Things, Big Data, QR codes, RFID, NFC, automation, supply chain management, microservices, technology development.

ABSTRACT

The research paper aimed to present modern technologies and approaches that have led to the digitalization of processes within various industries. During the paper, facilities that can be made available to optimize work mechanisms and improve the way in which various activities are carried out were explored. Thus, the role that software applications have in obtaining, distributing and marketing a product was highlighted, offering a new experience of acquisition and consumption and ensuring product traceability in the Internet of Things context.

The paper was structured to provide an overview of processes in various industries, highlighting the elements of traceability, and to define the conceptual framework of the withdrawal of non-compliant products, thus presenting the new technological perspectives through the proposed prototype and exemplifying the practical utility through relevant case studies and analyses. The division into dedicated chapters, derived from the main structural elements, which were previously stated, allowed the detailed exposition of economic, social and technological considerations.

From a technological perspective, related Internet of Things technologies, such as RFID and NFC, were highlighted, and how they can interact to provide modern solutions and solve problems identified across industries. The chapter initially included a review of the specialized literature on economic and technological perspectives in the business environment, continuing with the analysis of consumer profiles, an essential practice for personalizing shopping experiences and increasing customer loyalty, facilitating the transition to modern approaches.

Through integration with IoT, more efficient product monitoring was achieved, and the addition of an additional technological layer through Big Data processing techniques led to relevant results regarding the environment, logistics and distribution.

In the same context, RFID and NFC were analyzed in detail, with a focus on demonstrating their usefulness in product tracking and streamlining industrial processes. Their applicability has been doubled by the use of QR codes and barcodes to access details regarding a purchased good, highlighting new methods of automating processes and improving user experience, thus allowing for real-time identification and monitoring of products.

The main theme of the doctoral thesis revolved around the traceability of products, their management, the component processes and the associated degree of innovation. Thus, self-service facilities were presented, which offer customers a fast, safe and efficient purchasing experience, without interacting with dedicated staff, as a modern alternative to the marketing stage. Also, blockchain and modern IT solutions, such as ERP platforms and inventory management systems,

have streamlined management processes, having an impact on the production, transport and distribution stages. However, it has been identified in the specialized literature and mentioned in order to reflect possible risks, the fact that the implementation of modern technological perspectives involves high costs with the adaptation of the industry and consumers alike, being sometimes met with resistance to change and protests.

The conceptual framework was marked by the presentation of a challenge found in supply chain management, namely the withdrawal of non-compliant products, which remains a critical problem in most industries. The current state of the product recall process in Romania has highlighted the need for more efficient and transparent systems, and some of the modern tools such as QR codes, RFID and NFC have been taken into account to improve the way in which product monitoring and traceability are carried out.

The research methodology applied quantitative and qualitative studies to identify the state of the industries, consumer opinions and growth prospects. The statistics regarding the involvement of technology in industries in Romania and the European Union were interpreted, subsequently insisting on the food industry and how digitalization has impacted consumers in one way or another, changing their purchasing behavior and expectations. At the end of this chapter, a questionnaire was presented regarding the impact of a product recall on the image of the retailer, the results of which highlighted the need to establish efficient crisis management processes in order to maintain consumer trust.

Thus, by identifying the problem and searching for an innovative approach that would facilitate its solution, the paper continued with the chapter dedicated to the prototype proposed for implementation and the architecture of the solution, highlighting RFID, NFC technologies and practically exemplifying by alternating between NFC and QR. Usage scenarios were implemented that illustrate concrete situations of application of the concept and the phased plan for using the solution, thus facilitating the presentation of an application that brings benefits such as reducing reaction time in case of recall and faster product identification. The results obtained confirmed the efficiency of the prototype, paving the way for large-scale implementation in various industries.

By continuing to exemplify the prototype and offering practical perspectives on the use of the proposed solutions, some of the benefits that RFID, NFC or QR codes bring in the context of IoT integration were outlined. Therefore, specific situations were presented such as increasing the visibility of local producers in supermarkets through modern customer profiling and loyalty techniques, marketing products that are characterized by transparency in manufacturing and processing and other scenarios that can be applied within various commercial entities. The use of digital methods for creating a consumer profile highlighted how the proposed concept can have implications in marketing and advertising, creating new business opportunities and improving customer relationships. By highlighting the advantages and disadvantages of implementing a

modern approach, the social, economic and technological considerations that outlined the need to establish a balance between innovation and consistency were studied.

The implementation of these technologies in a broader context depended on certain premises that had to be considered and ensured, so as to allow the proposed software development. Among the premises are the initial investments in infrastructure, including RFID or NFC hardware components, data management systems and specialized personnel in the administration and maintenance of these technologies. Also, efficient communication and interoperability can only be achieved by establishing a collaboration between manufacturers, distributors and retailers, thus eliminating impediments such as reluctance to change. The high costs of implementation and maintenance, as well as the complexity of data management, were other possible obstacles that had to be taken into account when implementing the concept.

The proposed architecture offered a modern vision on how product traceability is achieved in the recall process. The challenges involved in its development will be further addressed by the author, as a research objective, with the aim of exploiting the potential of the proposed technologies to the maximum and, why not, with the desire to study other technological options compatible with the business scenario.

It is expected that the implementation of the proposed prototype will demonstrate the practicability and efficiency of an integrated approach to product recall, adding value to the existing literature and providing information that can represent the foundation of new research.

In conclusion, the transformative potential of modern technologies, in various industrial sectors, was highlighted during the research work. These technologies offer advanced solutions for inventory management, traceability and operational transparency, and their integration into commercial processes has led to the automation and digitalization of workflows, significantly contributing to increasing consumer satisfaction.

In turn, consumers tend to respond with loyalty to the implementations adopted by commercial entities, the latter having the aim of offering higher quality products and services. Thus, the use of these technologies proves to be a strategic necessity for ensuring long-term success and sustainability.