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Application of the Lean 4.0 Approach in services

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Abstract

The application of the lean 4.0 approach in service industries represents a significant step forward in enhancing efficiency, quality, and the value delivered to end users. Although the lean concept was originally developed for the manufacturing industry, its flexibility allows for successful implementation in sectors such as hospitality, financial services, and healthcare. This paper analyzes the problems and challenges associated with implementing the lean approach across various service sectors, with a particular focus on tools, methods, and achieved results. By using a combined qualitative and quantitative approach, the specific characteristics of each industry were identified and the impact of lean 4.0 tools on process optimization was analyzed. The findings indicate that the lean 4.0 approach, with appropriate adaptation, can significantly contribute to improving performance and the customer experience in service delivery.

Keywords

Lean 4.0, service industry, process optimization, digitalization, Industry 4.0, efficiency, customer experience

1. Introduction

Companies today face intense competition, rapid market changes, and constant demands for innovation, which can enable sustainable growth. These conditions require companies to adapt and continuously improve their operations in order to remain competitive and relevant. In such an environment, operational efficiency, product and service quality, and the ability to reduce costs have become key factors for the survival and success of businesses.

Technologies of industry 4.0, such as big data and analytics, are used to forecast market demand and gather real-time customer data, while tools like RFID and cloud computing enable immediate interaction with customers (Stojanović et al., 2023). The dynamic data obtained through big data analytics provides insights into the current state of the value stream map and supports decision-making in decentralized engineering.

The lean approach is a business methodology focused on waste reduction and continuous improvement by using resources in the most efficient way. The core principles of this approach include reducing cycle time, optimizing production processes, improving quality, and lowering costs, all aimed at achieving optimal efficiency. The main idea behind the lean approach is to create greater value for the end user through maximum efficiency, the reduction of all types of waste, and the elimination of unnecessary resource consumption.

Continuous improvement of business processes, a central element of the lean approach, is based on the Kaizen philosophy, which focuses on gradual but constant changes that bring long-term benefits in terms of productivity, quality, and market competitiveness.

The application of lean in various industries, including the service sector, enables significant improvements in process organization, reduction of waiting times, and increased customer satisfaction. It also contributes to better collaboration among employees and encourages team engagement in identifying and solving problems, which is crucial for operational efficiency. Although lean was initially developed for the manufacturing industry, its application has gradually expanded to other sectors such as services, healthcare, education, and the IT industry. The expansion of lean beyond manufacturing was made possible due to its flexibility and suitability for adapting to the specific needs of different industries (Bicheno & Holweg, 2009).

In healthcare lean principles are used to improve operational efficiency in hospitals and other healthcare facilities, affecting the optimization of workflows and reducing patient waiting times (Womack & Jones, 2003). In educational institutions, lean helps improve teaching and administrative processes, while in the IT industry, it contributes to faster product development and fewer errors in software solutions (Ohno, 1988). Various factors, such as organizational culture and the characteristics of the industry itself, play a key role in the success of lean implementation (Liker, 2004).

The research in this paper will focus on the challenges that businesses face when implementing lean in different cultural and operational contexts. It is important to note the impact of global economic pressures, primarily of a legal nature, on the success of lean initiatives, as well as how organizations overcome barriers related to changes in work culture and employee mindset (Cudney & Elrod, 2011). Implementing lean requires significant changes, not only on a technical level but also on an organizational level, as the success of implementation depends on the ability to support employees during the adaptation process and changes in work habits.

2. Literature Review

Quantitative and qualitative literature analysis represent different approaches in the research process. Quantitative analysis relies on statistical methods and numerical data, allowing researchers to test hypotheses and generalize results to broader populations (Bazeley, 2013). On the other hand, qualitative analysis focuses on a deeper understanding and interpretation of the content, context, and meaning within texts, exploring subjective aspects that are not quantified (Patton, 2015). While quantitative analysis provides more objective, data-driven measurements, qualitative analysis enables researchers to explore complex phenomena and develop theories (Flick, 2018). By combining both approaches, researchers can gain a comprehensive insight into the topic, using both statistical and interpretative methods simultaneously.

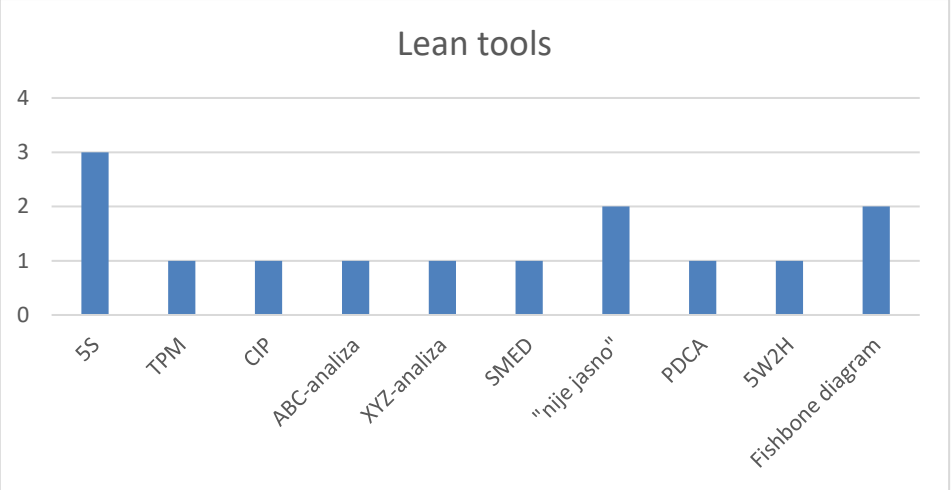
The quantitative analysis included eight papers, which were carefully read and analyzed based on six criteria: type of paper, year of publication, type of problem addressed, approach used in the paper, type of waste, type of lean tools used, and the results achieved through the application of lean.

The typology of the paper refers to what the paper describes, specifically whether the paper is theoretical or addresses the practical application of a concept. In this study, the papers were divided into three types: practical application (model and case study), theoretical work, and both practical application and theoretical work.

Two different streams of problems were identified in the analyzed papers. The first group of papers deals with services that accompany production work, such as maintenance, working conditions, and employee testing due to the nature of the work they perform. The second group focuses specifically on the service sector, such as hospitality, finance, and healthcare, which requires precisely defined procedures with little room for errors and customer dissatisfaction.

Through reading and analyzing the papers, several approaches used in the studies were identified, which were then categorized into three groups: maintenance, DMAIC, and IDI. It can be observed that lean philosophy and industry 4.0 approaches are applied in each paper, which was expected given the subject matter. Other approaches, such as Maintenance, DMAIC, and IDI, were used in the context of the specific nature of the industry addressed in the paper.

The reviewed papers identified several different lean tools that were used to address the described problems, while for two papers, it was not possible to determine the type of tools used, as this was not clearly stated. From the above, it can be concluded that the number of lean tools used is large. In this regard, it is very important to track which tools were most frequently used in practice and what results they achieved. To provide a clearer overview of the application of different lean tools in the reviewed literature, a graph (Graph 4) is presented below, which compares the frequency of appearance and the names of the lean tools used:



Graph 1 – Comparative display of the type of lean tools and their frequency of occurrence in the reviewed papers

It can be observed that the 5S tool is the most commonly used in the papers, followed by the cause-and-effect diagram (Fishbone diagram), while in some papers, it was not clearly identified which type of lean tool was used. The use of the 5S tool and the cause-and-effect diagram in service sectors is a frequent topic in scientific papers due to their ability to improve work organization and the efficiency of problem-solving.

The reviewed literature presents a large number of different results that authors have achieved through the application of lean approaches, i.e., the use of various lean tools in industries and organizations. It can be observed that productivity increase, waste reduction, and improved process efficiency are the most common types of results, which align with the core objectives and principles of lean as an approach that always seeks higher output with minimal input into the process.

Qualitative literature analysis is a research method that focuses on deeper understanding and interpretation of texts, placing special emphasis on meanings, values, and context. This approach enables researchers to analyze relevant sources and present key thematic or theoretical components in a specific field (Denzin & Lincoln, 2011). Qualitative analysis is of great importance in social and human sciences as it allows researchers to clarify subtleties that are not fully measurable by quantitative methods (Creswell, 2013). Through this analysis, researchers can gain deeper insights into subjective attitudes, beliefs, and social aspects, which provide a clearer picture of the phenomena being studied.

The papers subject to qualitative analysis are divided into three groups:

1. Papers related to the service sector and describing practical examples;
2. Papers referring to services that support the production process;
3. Theoretical papers connecting lean and industry 4.0.

In the existing literature, several examples of the application of lean management methods in the hospitality sector can be found. For instance, Starwood Hotels implemented Lean Six Sigma in 2001. Results said that the company achieved rapid gains in financial sector, with a 19% increase in revenue (Starwood, 2004). Yukai Resort in Japan operates with a minimal number of employees and reduced overall costs, while still maintaining high-quality services, thanks to lean management (Yukai Resort, 2017). Lean project was implemented at Apex Hotels saved around 5,700 working hours annually, improving guest services and working conditions for hotel staff (Apex Hotels, 2016). To enhance customer service, Marriott Hotel created twelve foundational leadership and service principles inspired by lean methodology (Marriott, 2017).

3. Problem description

The effectiveness of applying lean principles largely depends on the specific characteristics of the industrial sector, as well as the nature of the problems that need to be solved. With this in mind, in this paper, the issues will be systematized and analyzed across three sectors: hospitality, financial services, and healthcare.

3.1. Lean Approach for the Hospitality industry

The study also identified certain challenges. The main challenge put in front of the company was staff planning which was depending on hotel capacity utilization. On one hand, difficulties arose in making reliable forecasts of the number of people who have will to stay overnight and demographic profile of room occupants (the number of adults and children, as well as their ages). Another challenge was determining the required number of employees based on the number and type of guests. These challenges can also appear in production and can be coordinated using lean principles and capacity planning methods. To ensure that resource planning under lean principles better addresses customer expectations, the methods for forecasting and staff scheduling were revised. Various forecasting methods were analyzed (moving average, weighted moving average, exponential smoothing), with the weighted moving average with different weights chosen as the final method, as the most reliable.

3.2. Lean Approach for the Financial services

The financial services sector is primarily focused on the speed of procedures performed by administrative workers, and this reflects the quality of service. It is also important to note that with digitalization, all manual tasks are replaced by software and computers, thus minimizing the errors that workers previously made. A characteristic of this sector is a high level of data security and a large number of checks to ensure that all procedures are carried out in accordance with established rules. In this regard, companies operating in the financial sector are constantly striving to improve their processes.

A project was launched to improve one of the procedures involving both an employee and the service user. It consisted of the following steps: the user visits the website, fills out a form, and uploads the necessary documents. The employee at the company manually verifies the documents, enters the data from the documents into the system, marks the process as complete in the system, and notifies the user that the procedure is finished. The author (Klippa, 2022) provided a graphical representation of the process (Figure 1):

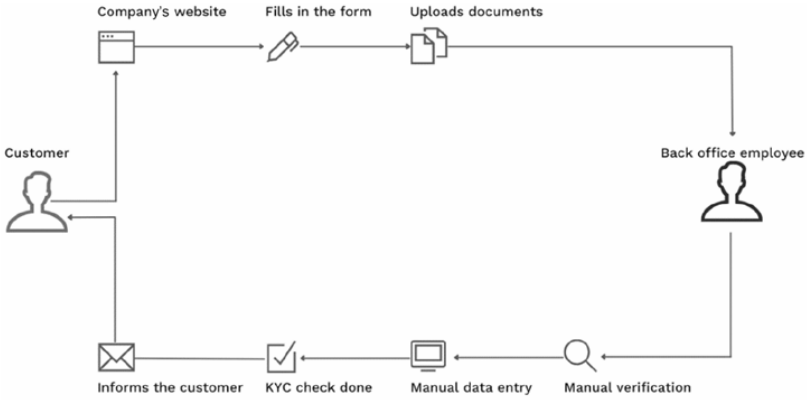


Figure 1 – Current state of the process in the financial institution (Lameijer et al., 2024)

3.3. Lean Approach for the Healthcare

In the paper by Arcidiacono & Pieroni (2018), the huge increase in costs and low efficiency levels are identified as the main reasons why the healthcare sector requires a new, cost-effective, and efficient management policy that places the user first, along with the dissatisfaction of the management of healthcare organizations. To achieve the desired goal, the authors believe it is necessary to develop an optimization policy that continuously supports doctors and healthcare workers. The idea was to combine knowledge of medical procedures with efficient healthcare delivery so that continuous improvement becomes a daily routine.

When an emergency arises, hospitals first admit the patient to the emergency department (ED), emergency care, where the patient is referred for further tests based on their condition. The department has a certain number of beds, based on the population living in the hospital's area, according to regulations set by law. The department is managed by a supervisor who is responsible for directing the person for further examination or providing guidance for the next steps. This process has been identified as critical, and the performance indicator used is the average time to hospitalization (MHT).

4. Research Methods

In the first phase of the analysis, during the review of titles, abstracts, and keywords, eight papers that were not directly related to the research field were excluded. Then, during the download of papers from the internet, twelve papers that were not available were excluded. A total of twenty-three papers were downloaded, which were thoroughly reviewed and analyzed. In this phase, an additional fifteen papers related to lean approach and industry 4.0, but focused on the manufacturing industry rather than services, were excluded. Finally, from the initial forty-three papers, eight papers remained for further research, which will form the basis for the work on the topic "Application of lean 4.0 Approach in Services".

The selection of papers was based on predefined criteria: relevance to the service sector, presence of lean 4.0 elements, and clearly documented implementation results. The analysis of the selected papers was conducted by combining qualitative and quantitative methodologies. The quantitative part involved the classification of papers according to the type of services, tools used, and outcomes achieved, while the qualitative part focused on identifying thematic patterns, challenges in implementation, and the degree of integration of the lean concept and industry 4.0. This approach allowed for a deeper understanding of the application of lean 4.0 methodology in service industries and the identification of best practices that can serve as guidelines for future research and implementations.

5. Results

The results of the application of lean principles vary significantly depending on the specific characteristics of the industrial sector and the type of identified problems. Accordingly, the results presented in this chapter will be classified into three sectors: hospitality, financial services, and healthcare.

5.1. Hospitality industry

The company in which the research was conducted is one of the largest and most prestigious hotels and spa centers in Italy, identified as a family-run establishment, having received multiple awards from certified bodies for evaluating hospitality facilities. The hotel operates year-round, has a maximum capacity of one hundred and four beds, and employs around one hundred and twenty people.

During the research, several lean principles and measures were applied, ranging from resource planning in relation to service users to continuous process improvement, warehouse management, and inventory control. The Pareto principle was used in two areas, as well as XYZ analysis, leading to the selection of specific suppliers with whom strategic partnerships were signed. Additionally, the system for quality control and expiration date monitoring was improved, as food and beverages offered by the company are a key part of the offering and significantly contribute to the quality of service provided to customers. The savings after applying lean principles in various aspects of hotel operations amount to approximately two hundred and fifty-one thousand euros annually.

5.2. Financial Services

In the context of applying lean principles in the financial services sector, to create a clear framework and overview of relevant participants in the process, the SIPOC model (Supplier, Input, Process, Output, Customer) was used. This model allows for the precise identification of key parties involved in the process. The process begins when business clients are identified as suitable for analysis, which means they meet a set of legal requirements where only basic parameters defined by law are analyzed, without the need for additional, enhanced analyses. The process ends when the files have been reviewed, either manually or through a robotic system. This approach allows for more efficient identification and management of processes, which aligns with the principles of lean, focusing on waste reduction and increasing value for the end customer. The implementation of lean principles in the financial services sector can contribute to better process organization, reduced processing time, and resource optimization, leading to greater efficiency and customer satisfaction. The authors (Lameijer, de Vries, Antony, Garza-Reyes, & Sony, n.d.) presented this graphically as follows (Figure 2):

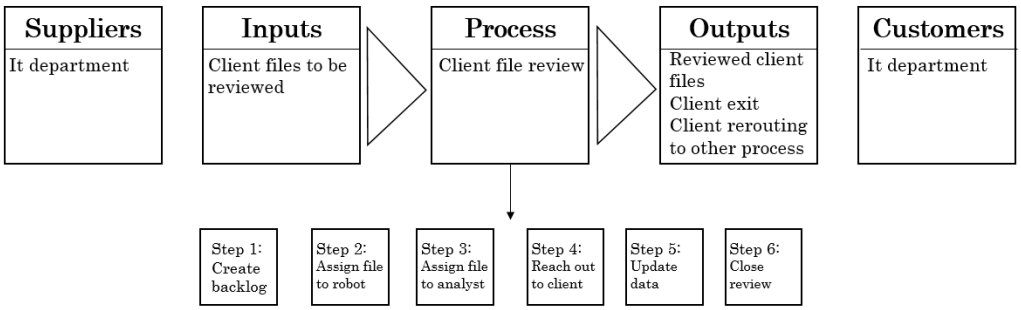


Figure 2 – SIPOC diagram of the financial services process, modified from (Lameijer et al., 2024)

The goal is to replace all manual operations with a program that will simultaneously handle data recording from documents, data validation, and data entry into the database. The author (Klippa, 2022) provided a graphical representation of the improved process (Figure 3):

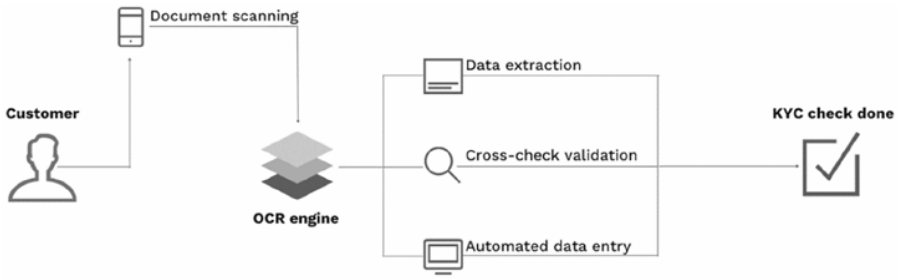


Figure 3 – Improved, automated process state in the financial institution (Lameijer et al., 2024)

The project brings numerous benefits to users and the business, as well as strategic advantages that enable more efficient functioning of the organization. In terms of benefits provided to users, the project eliminates unnecessary questions or restrictions related to risks that arise from incorrect assessments. As a result, users do not have to deal with potential issues related to inaccurate or imperfect assessments.

For the company, the benefits are reflected in the reduction of operational costs, achieved by reducing the number of full-time employees. Additionally, implementation costs are reduced due to less involvement of human resources. In this way, potential issues such as fines or restrictions related to the banking license, which might arise from extended deadlines or poorly performed assessments, are avoided.

Expected investments in the project include costs for analysts, team leaders, process managers, and data analysts, as well as costs for the development of the information system. For analysts, the expected annual investment is around two million euros, while the cost for team leaders and process managers is three hundred thousand euros and two hundred thousand euros annually, respectively. Costs for the development team include an investment of five hundred thousand euros for team formation, with further annual costs based on the service level agreement (SLA).

The greatest benefits of this project are reflected in direct savings, specifically cost reduction. For example, analysts are expected to complete one hundred and ten thousand reviews by the end of two thousand and twenty-two, with automation expected to handle sixty percent of the work. The remaining tasks would still have to be completed manually, which would require the engagement of an additional eight workers. The cost for these additional workers would be four hundred and eight thousand euros annually. Furthermore, reducing the number of process managers from five to two represents additional savings of three hundred and three thousand euros per year.

The software used addresses risk avoidance and non-monetary benefits, such as compliance with the Anti-Money Laundering and Terrorism Financing Act, better control of the steps taken in the process, and preventing the loss of the banking license. On a strategic level, the project enables the reduction of operational costs and improves the overall efficiency of business operations.

5.3. Healthcare industry

In this paper, the DMAIC procedure was applied, which consists of the following phases (Arcidiacono & Pieroni, 2018): Define, Measure, Analyze, Improve, and Control.

In the measurement phase, three different types of waiting times were identified:

1) Waiting for visit: the time elapsed between the registration of patients in the emergency department and the call for the first examination;
2) Waiting for evaluation: the time required for the healthcare evaluation of patients;
3) Waiting for admission to the department: the time elapsed from the completed evaluation to the actual registration of patients in the department. The authors developed an activity diagram, or mapped the process of admitting patients who need to be admitted to the department (Figure 4):

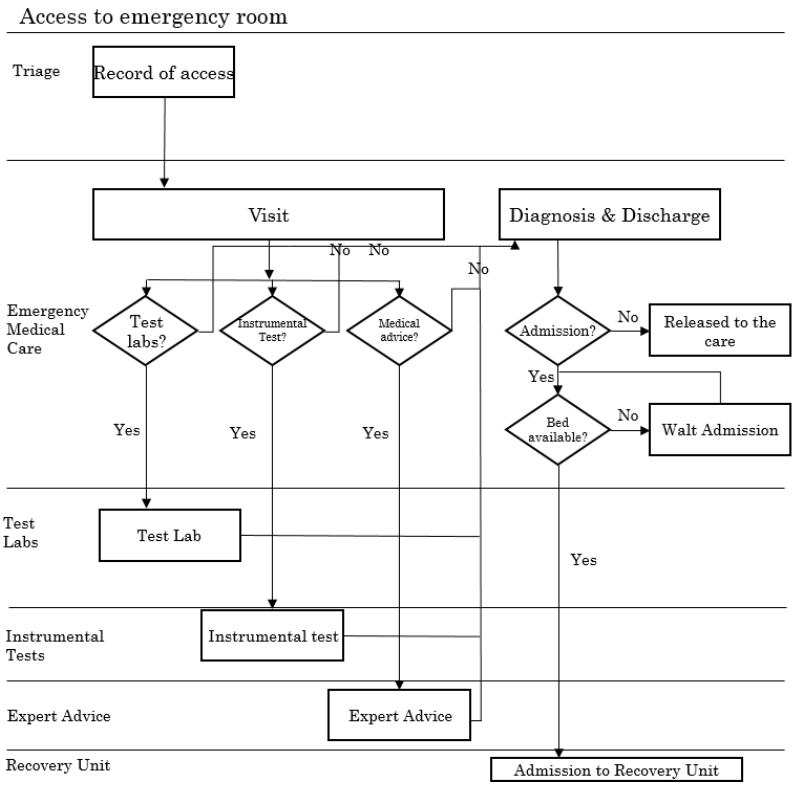


Figure 4 – Process map of the patient's movement from emergency examination to department admission, modified from (Arcidiacono & Pieroni, 2018)

During the research, it was noted that there is significant time variability in the process due to several reasons:

1) Lack of available beds;
2) Lack of specialists;
3) Lack of customer information about the health condition of users;
4) Lack of patient orientation upon arrival at the emergency examination.

It was also observed that the average waiting time in the emergency department is seven hundred and forty-two minutes, including the mean time to hospitalization (MHT). Only fifteen percent of all patients who need hospitalization have a mean time to hospitalization (MHT) of less than ten minutes.

In the next phase of the DMAIC methodology, a cause-and-effect diagram was used. The goal of its use is to identify the causes of anomalies in patient waiting times. Primarily, the observed process needs to have a lower mean time to hospitalization (MHT), but it is also necessary to reduce the variation of this performance from patient to patient. The cause-and-effect diagram developed by the authors Arcidiacono & Pieroni (2018) is shown in the following image (Figure 5):

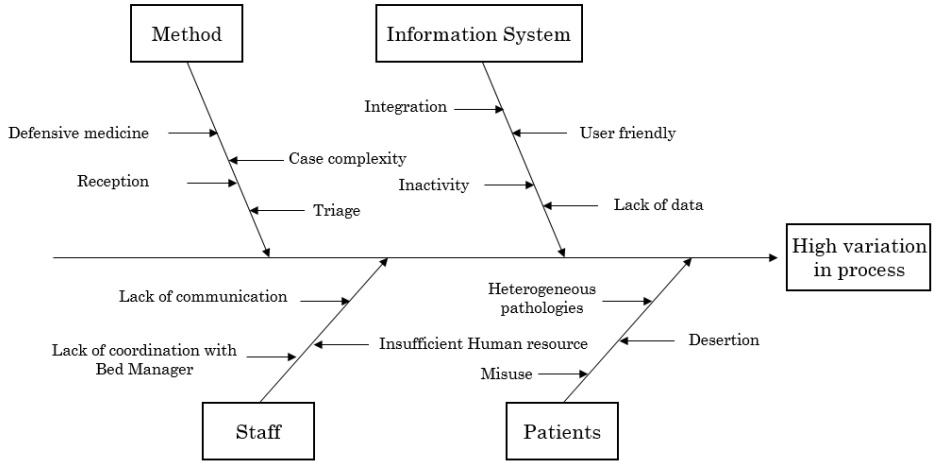


Figure 5 – Cause-and-effect diagram, modified from (Arcidiacono & Pieroni, 2018)

It can be observed that the main causes of the large differences in process execution time are divided into two groups: the human factor, which includes patients and staff, and the systemic factor, which includes work methods and the information system.

After identifying the potential causes of the identified problems, it is necessary to define solutions, that is, ways in which the existing problems can be overcome. At the beginning, depending on the number of free beds in the emergency department, a decision is made whether to admit the patient to the hospital or not. The auxiliary staff is not always certain about how many free beds are available at any given moment in the hospital, and the check is done manually. The staff walks around the hospital, checks rooms, and consults with other personnel. Since the hospital is a larger facility in terms of square footage, this manual procedure takes a lot of time. One possible solution would be to install sensors in the beds. The areas covered by the sensors would be under the pillow, under the torso, and under the legs, positioned beneath the mattress. The reason for this positioning is that the bed is considered occupied only when the person is lying down, that is, the person is in the system. This leads to the question: What if the person needs to get up, change their body position, and no longer lie down? Next to each bed, there would be a button that the staff would need to press, thus verifying that the bed is assigned to the person, that is, the person is indeed there. Only in the case of a double check, both the sensor and the verification button, can the system send the data that the bed is occupied. The data is sent to the network, processed according to a series principle, which is filled as long as there are free spots, and the staff at the reception desk receives information about the number of available spots in the series, that is, the number of free beds. The authors visually presented this process (Figure 6):

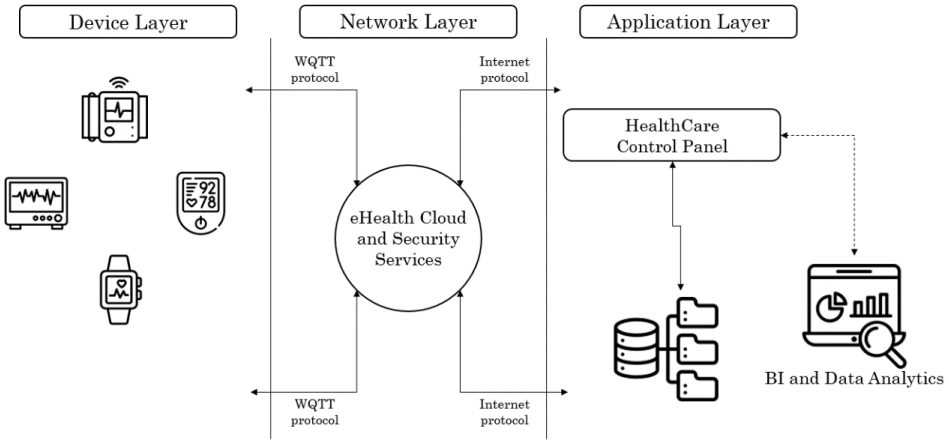


Figure 6 – Typical three-layer architecture of the required information system, modified from (Arcidiacono & Pieroni, 2018)

The data available through these devices are collected, stored, and analyzed using Business Intelligence technologies and Business Analytics methodologies to maintain automated countermeasures, with the goal of instant response to notifications or alarms.

6. Conclusion

In a rapidly changing world, the hospitality industry is forced to adapt its approaches to trends. Technology is advancing day by day, which has led to changes in working techniques and approaches in hospitality, now directed towards the smart hospitality industry (Almeida, 2016). Mechanization, electrification, computer processing, and digitalization of tasks mean that the world is currently in the era of the Internet of Things (IoT) or the fourth industrial revolution, known as industry 4.0 (Kagermann et al., 2013). Innovations during the fourth industrial revolution, focused on creating value in hospitality, have become increasingly important (Ivanovic et al., 2016). Data collection and big data analysis have become key to better understanding critical issues in hospitality, such as the relationship between guest experiences in hotels and their satisfaction. Big data analysis can bring new insights into variables that have already been extensively studied in the existing literature on hospitality (Xiang et al., 2015).

Digitalization appears as a trend that has a significant impact on the development of lean principles and tools. According to Matt et al. (2016), Industry 4.0 does not replace lean principles but introduces new technological tools through which lean principles can be properly developed. Through new and advanced technologies and concepts listed under the term industry 4.0, lean principles can be implemented better and more consistently than ever before.

Developing and improving services has become an essential part of daily operations for organizations, both service and manufacturing industries. Customer involvement becomes very important in the 21st century industry due to the continuous feedback provided by IoT devices, through social media or digital surveys. Data from clients are collected and have a significant impact on real-time service adaptation, procedure design based on needs, and providing feedback after the completion of the process.

Big Data represents a significant leap towards collecting feedback from all participants in the value chain, as it allows for control, ensuring that the end user receives the product or service

with the highest value. Only through the joint efforts of all, creating value strives for perfection.

The integration of lean production with industry 4.0 technologies can generate a powerful synergy that leads to substantial improvements in efficiency, productivity, and quality. By aligning these approaches, companies can increase agility and competitiveness, respond more effectively to customer demands, and ultimately enhance profitability and growth (Stojanović et al., 2023).

Technological advancement within industry 4.0 enables high levels of automation and service personalization, making the application of lean 4.0 approaches even more efficient in service industries. However, the success of this application depends not only on the implementation of technology but also on continuous investment in the development of new tools and methods for monitoring and analyzing user behavior. This approach allows organizations to not only adapt to the current market needs but also to anticipate its future changes.

To achieve long-term results, it is important for organizations to invest in continuous learning and training of their employees to effectively deal with new technologies and methodologies. Leaders in the service sector should integrate lean 4.0 principles into their business strategies, promoting a culture of innovation and agility. Only in this way will they be able to handle the challenges brought by rapid technological advancement.

Personally, I believe that additional effort should be made to adapt services to each individual user, as the strategic goal of an organization is to establish strong and long-term relationships with all stakeholders, with users being the key. Now, more than ever, Industry 4.0 and the tools that come with it provide the opportunity to track and record specific needs, while lean offers the necessary steps to determine critical areas for improvement.

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