MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
Sumy State University
Academic and Research Institute of Business, Economics and Management
Department of economic cybernetics

«Admitted to the defense»
Head of Department
_____ Koibichuk V. V.
(signature) (First and LAST NAME)
_____ _____ 20__ p.

QUALIFICATION WORK

to obtain an educational degree bachelor
(bachelor / master)

from the specialty 051 "Economics»_____,
(code and name)

educational-professional programs Business Analytics
(educational-professional / educational-scientific) (the name of the program)

on the topic: Developing a System for Automated Monitoring of the Procurement Process Using Digital Technologies and Analyzing the Results of Previous Procurements

Winner(s) of the group AB-91a.an Havrylenko Mariia Oleksandrivna
(group cipher) (full name)

The qualification work contains the results of own research. The use of ideas, results and texts of other authors are linked to the corresponding source

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Consultant_____ _____
(position, academic degree, academic title, Name and SURNAME) (signature)

Sumy – 2023

SUMMARY

bachelor's thesis on the topic

" Developing a System for Automated Monitoring of the Procurement Process Using Digital Technologies and Analyzing the Results of Previous Procurements "

student Havrylenko Mariia Oleksandrivna

(last name, first name, patronymic of the student)

The relevance of the topic chosen for research is determined by the fact that more and more companies are beginning to automate their production. To improve the overall condition of the company, it is necessary to restructure it, so some basic and secondary processes need to be reorganized, namely - automation.

The purpose of the qualification work is to develop a system for automated monitoring of the procurement process using digital technologies and analysis of the results of previous procurements.

The object of the study is the process of automating procurement in production.

The subject of the study is the process of purchasing goods for faster procurement for enterprises.

The objectives of the study are to study the essence of procurement process automation, analyze existing applications used for this purpose, and implement procurement automation.

The information base of the qualification work is based on various studies in the field of automation and available sites with supply services.

The main scientific result of the qualification work is the following: the procurement process in everyday life and at work was analyzed, and a table was developed that will make the data analysis process much easier for the company and allow it to order goods on time.

The results obtained can be used by firms that have to supply goods to their enterprises to automate the procurement process.

Keywords: automation, procurement, enterprise, automation of the procurement process

The content of the qualification work is presented on 30 pages. List of used sources from 21 names, placed on 3 pages. The paper contains 17 figures and 2 appendices on 9 pages.

Year of qualification work - 2023 years.

Year of work protection - 2023 years.

Ministry of Education and Science of Ukraine
Sumy State University
Educational and Research Institute of Business, Economics and Management
Department of Economic Cybernetics

APPROVE
Head of Department
Candidate of Economics, associate professor
_____ Koibichuk V. V.
"__" _____ 2023.

TASKS FOR THE QUALIFICATION WORK OF THE BACHELOR

specialty 051 "Economics" (Business Analytics)

4th year student, group AB-91a.an

Havrylenko Mariia Oleksandrivna
(last name, first name, patronymic of the student)

1. Topic of the work: Developing a System for Automated Monitoring of the Procurement Process Using Digital Technologies and Analyzing the Results of Previous Procurements
   approved be order of the university «23» 05 2023 № 0553-VI
2. The deadline for submission of completed work by the student «16» 06 2023
3. The purpose of the qualification work: develop an automated service for enterprise procurement.
4. The object of study: is the process of automating procurement in production
5. The subject of study: the process of purchasing goods for faster procurement for enterprises.
6. The qualification work is performed on materials: is based on various studies in the field of automation and available sites with supply services.
7. Indicative plan of qualification work, terms of submission of sections to the head and the maintenance of tasks for performance of the set purpose
   Chapter 1. ANALYSIS OF MODERN APPROACHES TO PROCUREMENT PROCESS MONITORING
   (name – submission deadline)

   In chapter 1.
   1.1 Overview of existing procurement process monitoring systems
   1.2. Use of digital technologies in procurement monitoring
   1.3. Analysis of data analytics to improve the procurement process
   (the content of specific tasks to the section that the student must perform)

   Chapter 2. DEVELOPMENT OF AN AUTOMATED PROCUREMENT PROCESS MONITORING SYSTEM
(name – submission deadline)

In chapter 2.
2.1. Definition of requirements for monitoring system
2.2. Technical specification and selection of necessary technologies
2.3. Development of an automated procurement process monitoring system
2.4. Evaluation of expected effect from implementing the automation system
(the content of specific tasks to the section that the student must perform)

8. Consultations on work:

Chapter	Surname, initials and position of consultant	Signature, date	
		Task issued by	Task accepted by
1			
2			

9. Date of issue of the task: «03» 04 2023

Supervisor _____ Koibichuk V. V.
(signature) (initials, surname)

Received the task to perform _____ Havrylenko M.O.
(signature) (initials, surname)

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INTRODUCTION

In today's fast-paced business environment, effective procurement processes play a crucial role in ensuring the smooth operation and success of organizations. However, managing and monitoring the procurement process can be a complex and time-consuming task, prone to human error and inefficiencies. To address these challenges, businesses are increasingly turning to digital technologies to automate and streamline their procurement processes.

This topic focuses on the development of a system for automated monitoring of the procurement process using digital technologies and leveraging the analysis of previous procurements. By harnessing the power of automation and data analytics, organizations can gain valuable insights into their procurement activities, identify areas for improvement, and make informed decisions to optimize their procurement strategies.

Automated monitoring of the procurement process involves utilizing digital tools and software solutions to track various stages of procurement, including requisition, supplier selection, purchase order issuance, goods or services delivery, and invoice processing. By implementing such a system, organizations can enhance transparency, reduce the risk of fraud, improve compliance, and achieve greater efficiency in their procurement operations.

Furthermore, analyzing the results of previous procurements provides organizations with a wealth of data and actionable intelligence. By examining historical procurement data, organizations can identify patterns, trends, and key performance indicators (KPIs) related to supplier performance, cost savings, contract negotiations, and overall procurement effectiveness. This analysis empowers organizations to make data-driven decisions, optimize their procurement strategies, negotiate better deals, and mitigate risks.

The combination of automated monitoring and analysis of previous procurements presents significant benefits to organizations. It enables them to enhance accountability, reduce manual errors, increase process efficiency, and drive cost savings. Additionally, the insights gained from data analysis can facilitate strategic planning, supplier relationship management, and continuous improvement in the procurement process.

The purpose of this diploma project is to facilitate the procurement process by

analyzing past procurements.

The object of research is the automation of the procurement process.

In conclusion, the development of a system for automated monitoring of the procurement process using digital technologies and analyzing the results of previous procurements holds immense potential for organizations seeking to optimize their procurement operations. By leveraging automation and data analytics, organizations can enhance transparency, efficiency, and decision-making capabilities, leading to improved procurement outcomes and a competitive edge in the market.

SECTION 1. ANALYSIS OF MODERN APPROACHES TO PROCUREMENT PROCESS MONITORING

1.1. Overview of existing procurement process monitoring systems

The monitoring of procurement processes has evolved significantly in recent years, thanks to advancements in digital technologies. Modern approaches to procurement process monitoring focus on utilizing innovative tools and techniques to improve transparency, efficiency, and compliance throughout the procurement lifecycle. Here, we will analyze some of these approaches and their impact on organizations.

Automation and Digitization: One of the key advancements in procurement process monitoring is the automation and digitization of various procurement activities. Organizations are increasingly adopting procurement management systems that enable seamless tracking of procurement processes from requisition to payment. These systems automate repetitive tasks, such as purchase order creation, invoice matching, and payment processing, reducing the likelihood of errors and speeding up the overall procurement cycle.

Real-time Tracking and Visibility: Modern approaches emphasize real-time tracking and visibility into procurement activities. With the help of digital technologies like cloud-based platforms and mobile applications, stakeholders can monitor the progress of procurement processes at any time and from anywhere. Real-time visibility enables better collaboration between different departments involved in the procurement process and improves decision-making by providing timely and accurate information.

Data Analytics and Insights: Another significant aspect of modern procurement process monitoring is the utilization of data analytics and insights. By analyzing large volumes of procurement data, organizations can gain valuable insights into supplier performance, price trends, contract compliance, and risk management. Advanced analytics techniques, such as predictive modeling and machine learning, can help identify patterns and anomalies, enabling proactive decision-making and strategic planning.

Supplier Performance Management: Effective monitoring of supplier performance is

critical for successful procurement operations. Modern approaches employ digital tools to track and evaluate supplier performance based on predefined metrics, such as on-time delivery, quality, and customer satisfaction. By monitoring supplier performance in real-time, organizations can identify underperforming suppliers, address issues promptly, and make informed decisions regarding supplier relationships and contracts.

Compliance and Risk Management: Ensuring compliance with regulatory requirements and mitigating procurement risks are top priorities for organizations. Modern monitoring approaches integrate compliance and risk management functionalities into procurement management systems. These systems incorporate built-in compliance checks, automate risk assessments, and provide alerts for potential non-compliance or risk incidents. Such proactive monitoring helps organizations maintain regulatory adherence and minimize potential disruptions in the procurement process.

Integration with Supply Chain: Modern procurement process monitoring approaches recognize the interconnectedness of procurement with the broader supply chain. Integration with supply chain management systems and other relevant platforms enables end-to-end visibility, seamless data flow, and efficient coordination between procurement, logistics, and inventory management. This integration enhances overall supply chain performance and optimizes procurement decisions based on real-time demand and supply information.

The aim of the thesis is to automate the procurement monitoring process using digital technologies and analyze the results of previous procurements.

To achieve this goal, you need to:

1. Research existing procurement monitoring systems.
2. Explore the use of digital technologies in procurement monitoring.
3. Analyze the use of data analytics to improve the procurement process.

Today, there are many ways to monitor procurement for different areas of work. But before I tell you about them, I need to explain what procurement monitoring is. Procurement monitoring is the analysis of the customer's compliance with public procurement legislation at all stages of procurement in order to prevent violations of public procurement legislation. [5]

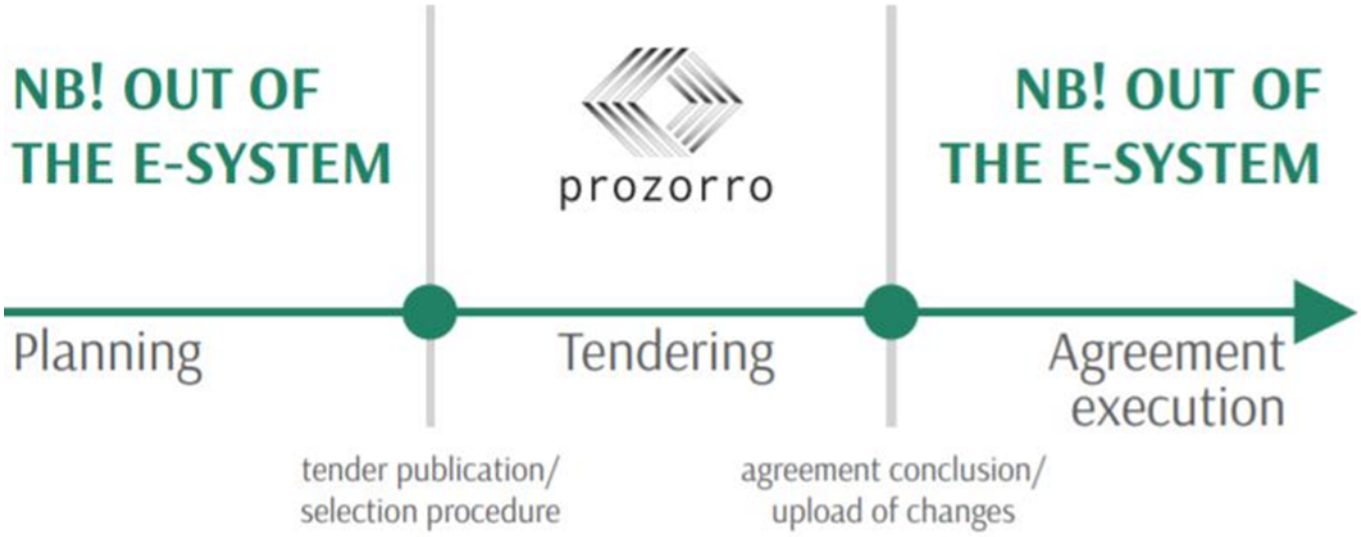

Figure 1.1. Displaying the purchase process on the ProZorro website

Here are examples of monitoring systems, namely: phone apps, websites, and the public procurement system ProZoro. Let us consider each of these examples:

1. Apps on the phone - programs that have been created by companies to make it easy to use the service they provide. Examples: NP (Nova Poshta), Glovo (courier delivery of groceries and medicines), Ukrposhta, Planeta Kino.
2. Internet sites - sites that allow you to conveniently purchase a particular product. Examples: Prom.ua (https://prom.ua/) [3], Moyo.ua (https://www.moyo.ua/ua/) [2]
3. Public procurement system - websites, tender programs that help to buy real estate or some securities. Examples: salesbook (https://salesbook.com.ua/uk/) [4], ProZoro (https://www.dzo.com.ua/) [1].

Figure 1.2. Logo of Facebook page ProZorro

1.2. Use of digital technologies in procurement monitoring

The use of digital technologies in procurement monitoring plays an important role in improving transparency, efficiency and prevention of corruption in procurement procedures. Below are some of the tools and methods used for this purpose.[7-8]

Electronic trading platforms: These are platforms that allow for electronic procurement. They provide a digital environment for bidding, publishing procurement information, receiving bids from suppliers and conducting an electronic auction. This allows for openness and competition in the procurement process.

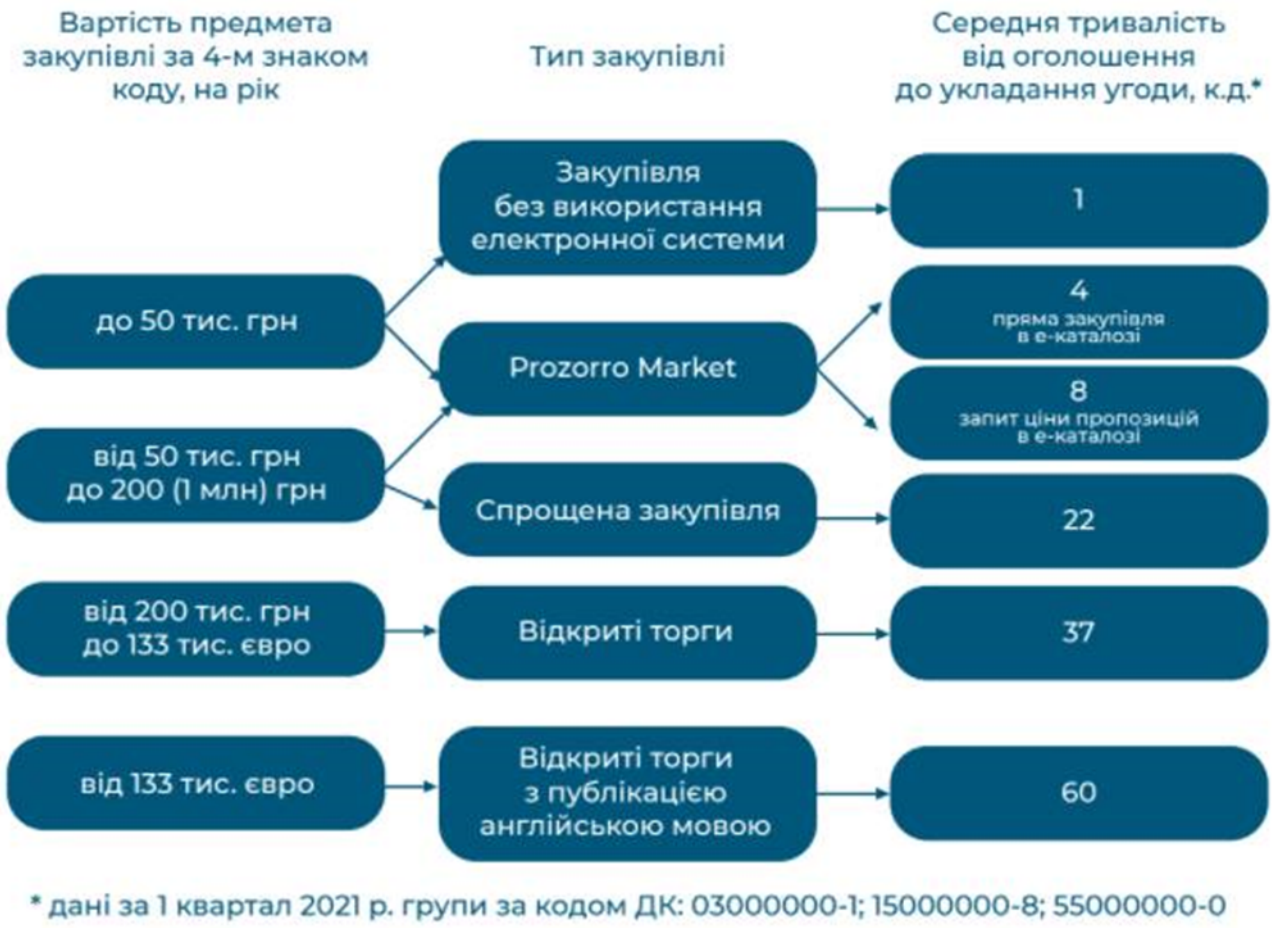

Figure 1.3. Procurement process on the website ProZorro.ua

Electronic document management systems: These systems allow for the electronic exchange of documents related to the procurement process. They provide storage and access control to documents, which simplifies communication between customers and

suppliers, and allows you to store all the necessary procurement documentation.

Analytics and artificial intelligence: The use of data analytics and artificial intelligence allows automated analysis of large amounts of procurement information. This can include anomaly detection, corruption risk assessment, evaluation of the procurement process efficiency and recommendations on optimal procurement strategies.

Open data and standardization: Publication of open procurement data allows the public and stakeholders to track and analyze procurement processes. Standardization of the data format and nomenclature facilitates interoperability between different systems and provides convenient access to information.

Electronic verification and electronic signature: The use of electronic verification and electronic signature allows you to verify the authenticity and integrity of procurement-related documents. This helps to avoid forgery and provides confidence in the legitimacy of documents.

These technologies help to diversify procurement processes, reduce the risk of corruption, and promote more transparent and efficient procurement. They also help automate routine tasks, provide quick access to information, and facilitate collaboration between all parties involved in the procurement process.

1.3. Analysis of data analytics to improve the procurement process

The analysis of data analytics to improve the procurement process is an effective approach that leverages the power of data to enhance efficiency, effectiveness, and decision-making in procurement activities. Here are some key aspects of this analysis [9-15]:

Demand forecasting: Data analytics can be used to analyze historical procurement data, market trends, and other relevant factors to forecast future demand accurately. This enables organizations to plan their procurement activities more effectively, ensuring the availability of necessary goods and services while minimizing inventory costs and stockouts.

Supplier performance evaluation: By analyzing data related to supplier performance, such as delivery times, quality of goods/services, pricing, and customer satisfaction,

organizations can objectively assess suppliers' performance. This helps in identifying top-performing suppliers, negotiating better contracts, and making informed decisions when selecting suppliers.

Figure 1.4. The number of out-of-home eating establishments

Cost optimization: Data analytics enables organizations to identify opportunities for cost optimization throughout the procurement process. By analyzing spending patterns, identifying areas of excessive spending, and benchmarking against industry standards, organizations can make data-driven decisions to negotiate better prices, consolidate suppliers, and implement cost-saving measures.

Risk management: Data analytics plays a crucial role in identifying and managing risks in procurement. By analyzing supplier data, financial indicators, market conditions, and other relevant factors, organizations can identify potential risks, such as supplier insolvency, delivery delays, or compliance issues. This allows for proactive risk mitigation strategies and contingency planning.

Process improvement: Data analytics provides valuable insights into the efficiency and effectiveness of procurement processes. By analyzing process data, organizations can identify bottlenecks, inefficiencies, and areas for improvement. This can lead to streamlining processes, reducing cycle times, and enhancing overall operational performance.

Compliance and fraud detection: Data analytics can help in detecting non-compliant or fraudulent activities in the procurement process. By analyzing procurement data and applying advanced algorithms, organizations can identify suspicious patterns, anomalies, or deviations from established rules and regulations. This facilitates early detection and prevention of fraud, ensuring transparency and integrity in the procurement process.

In conclusion, leveraging data analytics in procurement enables organizations to make data-driven decisions, optimize costs, mitigate risks, improve processes, and ensure compliance. By harnessing the power of data, organizations can achieve greater efficiency, transparency, and value in their procurement activities.

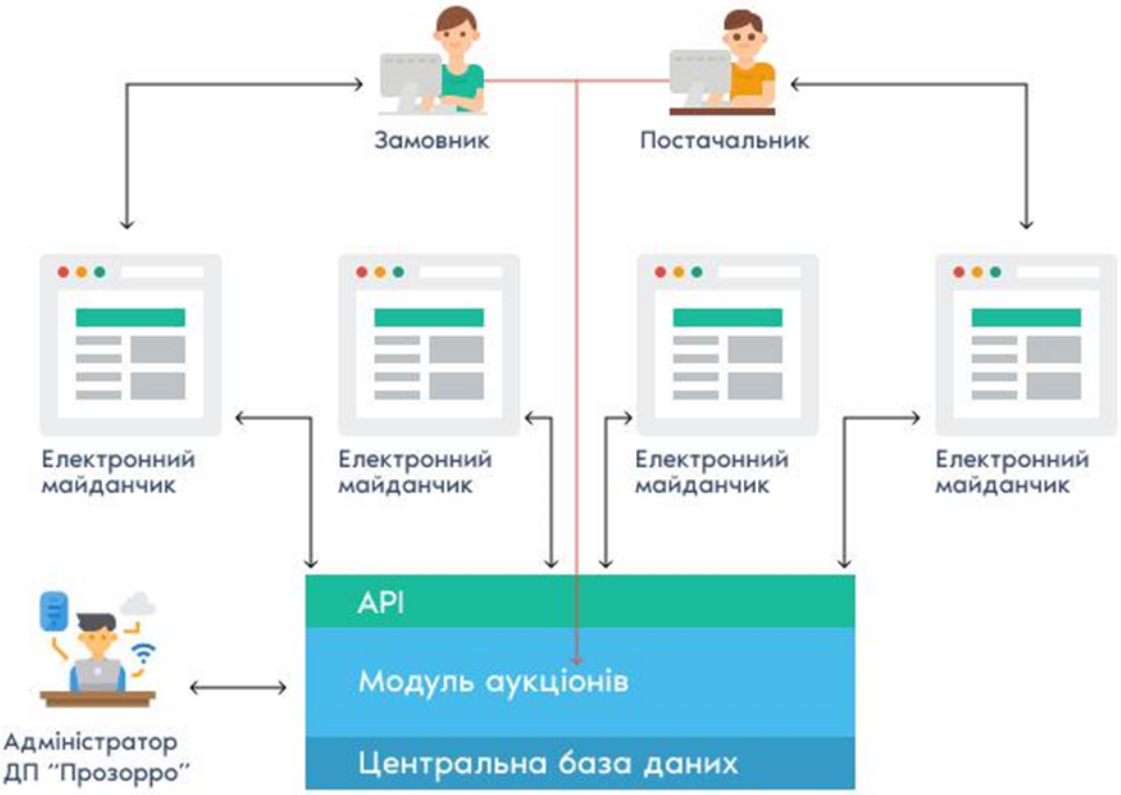

Figure 1.5. Process of buying some things

SECTION II. DEVELOPMENT OF AN AUTOMATED PROCUREMENT PROCESS MONITORING SYSTEM

2.1. Definition of requirements for monitoring system

The development of an automated monitoring system for the procurement process involves designing and implementing a digital solution that leverages technology to streamline and enhance the monitoring and oversight of procurement activities. This system aims to automate manual tasks, improve transparency, and provide real-time visibility into the procurement process. Here are the key steps involved in developing such a system [6, 16-19].

Requirement Analysis: The first step is to analyze the specific requirements and objectives of the organization's procurement process. This involves understanding the existing procurement workflow, identifying pain points, and defining the desired functionalities and outcomes of the automated monitoring system. Stakeholder engagement and collaboration are crucial during this phase to ensure that the system aligns with the organization's needs.

Technology Selection: Based on the requirements analysis, appropriate digital technologies and tools need to be selected. This may include e-procurement platforms, workflow automation software, data analytics tools, and integration capabilities with existing procurement systems or ERPs (Enterprise Resource Planning). The chosen technologies should align with the organization's infrastructure, scalability needs, and security requirements.

System Design and Configuration: Once the technologies are selected, the system design phase begins. This involves creating a blueprint or architectural framework for the automated monitoring system. The design should consider factors such as data flow, user interfaces, process automation, data security measures, and reporting capabilities. Configuration and customization of the selected technologies are also performed during this

phase to align them with the organization's specific requirements.

Data Integration: The automated monitoring system needs to be integrated with relevant data sources, such as supplier databases, contract management systems, inventory systems, and financial systems. This integration allows the system to retrieve and consolidate data related to procurement activities, including purchase orders, invoices, supplier information, and contract details. Data integration ensures accurate and up-to-date information for monitoring and analysis purposes.

Workflow Automation: The core functionality of the system involves automating the procurement workflow. This includes defining and configuring workflows for various procurement stages, such as requisition, supplier selection, purchase order creation, goods receipt, and invoice processing. Workflow automation ensures consistent and standardized processes while reducing manual intervention, errors, and delays. The system should provide notifications, alerts, and escalations to relevant stakeholders at each stage of the procurement process.

Real-time Monitoring and Reporting: The automated monitoring system should provide real-time visibility into the procurement process. It should enable stakeholders to track the progress of procurement activities, monitor key performance indicators (KPIs), and identify bottlenecks or exceptions that require attention. The system should generate comprehensive reports and dashboards that present data and analytics related to procurement performance, cost savings, supplier performance, and compliance.

Security and Compliance: Data security and compliance are critical aspects of an automated monitoring system for procurement. The system should incorporate appropriate security measures, such as access controls, encryption, and data backup mechanisms, to protect sensitive procurement data. Compliance with relevant regulations and standards, such as data privacy laws or industry-specific requirements, should be ensured during the development and implementation of the system.

Testing and Deployment: Before deploying the automated monitoring system, thorough testing is essential to identify and rectify any functional or technical issues. This includes unit testing, integration testing, and user acceptance testing. Once the system passes testing, it can be deployed to production environments. User training and change management activities should accompany the deployment to ensure smooth adoption and

utilization of the system.

Continuous Improvement and Maintenance: The development of the automated monitoring system doesn't end with deployment. Continuous improvement and maintenance are necessary to address evolving requirements, incorporate user feedback, and ensure the system's optimal performance. Regular updates, bug fixes, and enhancements may be required to adapt to changing business needs and technological advancements.

In conclusion, the development of an automated monitoring system for the procurement process involves a systematic approach that encompasses requirement analysis, technology selection, system design, data integration, workflow automation, real-time monitoring, security, testing, deployment, and ongoing maintenance. Such a system enables organizations to streamline procurement operations, improve transparency, and make data-driven decisions, ultimately leading to greater efficiency and effectiveness in the procurement process.

Defining requirements for a monitoring system involves identifying and analyzing the needs and specifications that should be considered when developing the monitoring system. The main goal of this process is to determine the functional, non-functional, and technical requirements that the monitoring system must fulfill in order to achieve the organization's objectives. Here are several key steps in defining requirements for a monitoring system.

Stakeholder Engagement: Engage with various stakeholders such as management, procurement experts, finance, IT, and other departments to understand their needs, challenges, and expectations from the monitoring system. Conduct interviews, surveys, or focus groups to gather diverse perspectives and ideas.

Analysis of Current Monitoring Process: Thoroughly analyze the current methods and processes used for monitoring, which are employed in the organization. Identify their advantages, limitations, constraints, and opportunities for improvement. Identifying problematic areas will help determine the necessary requirements for the new monitoring system.

Definition of Functional Requirements: Establish the functions that the monitoring system should perform. These may include automated tracking of procurement operations, reminders for critical dates, analysis of procurement results, and report generation, among others. Compile a list of functions that are essential for achieving the organization's goals

and requirements.

Establishment of Non-functional Requirements: Determine the non-functional requirements that impact the quality and effectiveness of the monitoring system. These may include performance, security, scalability, accessibility, user interface, and others. For example, the system may require real-time availability of information or high resilience to data breaches.

Technical Requirements: Identify technical requirements related to hardware and software, integration with existing systems, scalability, data security, and others. This includes choosing the platform, database, programming languages, data transmission protocols, and other technical aspects.

Documentation of Requirements: Document all the requirements in a specification document such as a "Requirements Specification" or "Technical Specification." This document should encompass all the functional, non-functional, and technical requirements identified in the previous stages.

Verification and Approval of Requirements: Present the requirements document to stakeholders and relevant departments for review, approval, and consensus. Ensure that all requirements align with the organization's needs and can be technically implemented.

Defining requirements for a monitoring system is an important stage that establishes the foundation for developing a monitoring system that meets the organization's needs and leads to improved efficiency and effectiveness in the procurement process. This process requires thorough analysis, stakeholder engagement, and documentation of all requirements for the subsequent development and implementation of the monitoring system.

2.2. Technical specification and selection of necessary technologies

Project objective: Develop a web application to automate the procurement tracking process.

Description of functionality: The main functionality of the web application should include the following:

1. Creating, editing, and deleting a product list.

- The user must be able to create new product items, specifying their name and cost per day.
- The user must be able to edit existing product items.
- The user must be able to delete product items.

2. Viewing the list of the last dates of ordering products.
    - The user should be able to view a list of product items that have been ordered, along with the dates of their last order.
3. Analysis of the current list of products.
    - The user should be able to visually track the items in the product list for easy ordering of products.

Structure of the web application: The web application should contain the following pages:

1. Home page ("Home"):
    - On this page, the user has the opportunity to view the list of product items.
    - In case of necessity of additional ordering, the user should visually see such items in the list.
2. Product management page ("Products"):
    - On this page, the user has the ability to create new product items, specifying their name and cost per day.
3. Page for viewing information about orders ("Deliveries"):
    - On this page, the user can view a list of all items that have been ordered and the dates of their order.

The web application can be expanded in the future, with the following functionality:

1. Supplier management:
    - Adding and editing information about suppliers.
    - Linkage to product items and orders.
2. Automatic ordering mechanism:
    - Automatic creation of an order in case of need for additional orders.
    - Integration with suppliers and delivery system.
3. Statistical analysis:

- Collection and display of statistical data on orders, costs and available products.

2.3. Development of an automated procurement process monitoring system

The MERN technology stack (MongoDB, Express.js, React.js, Node.js) was chosen to develop the system as a web application. This technology stack is one of the most popular stacks for developing web applications. Here are some of the advantages of using the MERN stack:

- Each component of the MERN stack can be used separately or together with other technologies, depending on the needs of the project.
- All components of the MERN stack are based on JavaScript. This means that a single programming language is used at all levels of the application, which simplifies communication and increases development speed.
- With the help of the React.js library, applications are created that are instantly updated without reloading the page. This provides a smoother and more interactive user experience [20].

The first page «Production» (Figure 2.1) contains a list of all items that have been added to the web application database, as well as the total number of these items.

Figure 2.1. Production page

The page also contains the «Add/Edit Product» form with two fields «Title» and «Consumption», respectively (Figure 2.2).

Figure 2.2. Add/Edit Product form

After filling in the form fields and clicking the «Add» button, the new record will be added to the database (Figure 2.3).

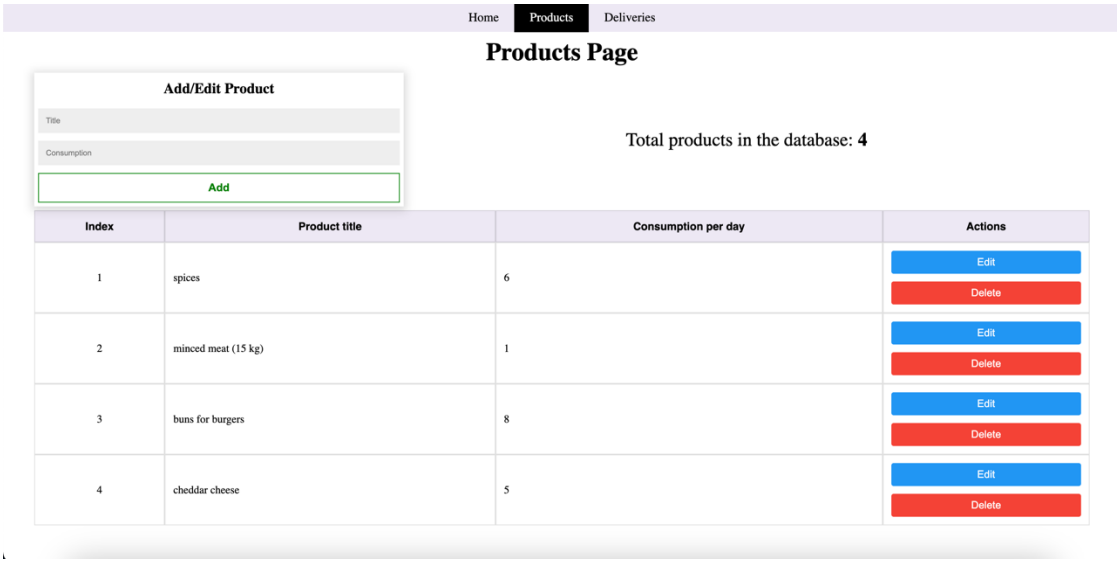

Figure 2.3. List of products

Each item has two buttons with the corresponding functionality. The «Delete» button is used to delete an item from the database. The «Edit» button switches the form to the editing mode, where you can change the item data (Figure 2.4). After making changes and clicking the «Edit» button, the updated data will be saved in the database.

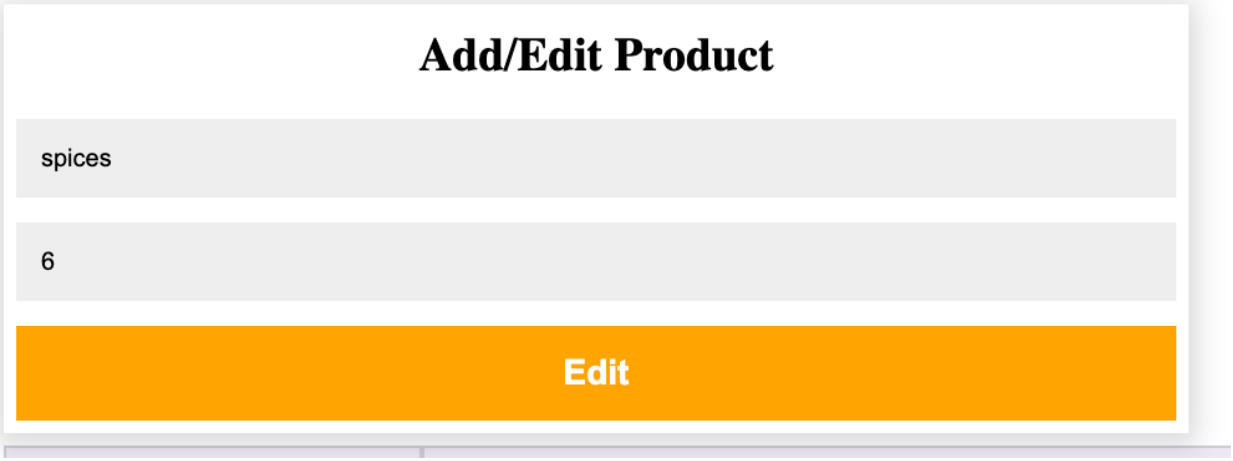

Figure 2.5. Edit form

The next page «Home» (Figure 2.6) displays a list of all items that need to be ordered. All items are visually marked in red because the dates of the last orders have not yet been entered into the system.

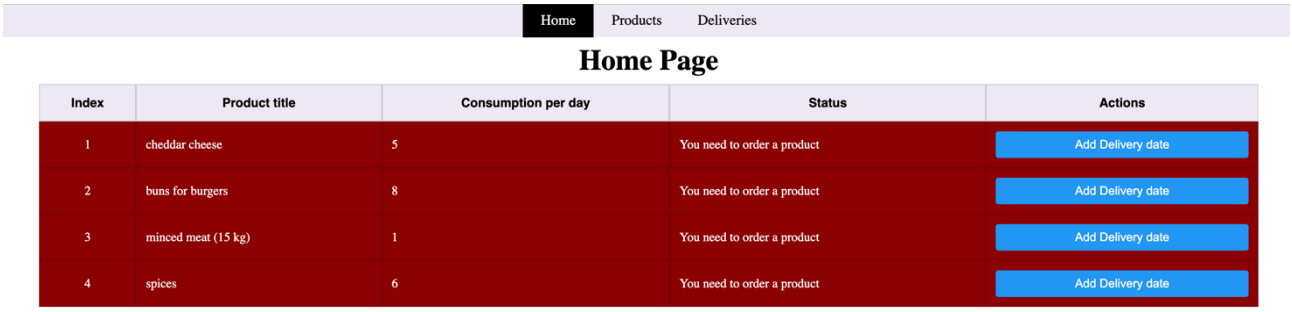

Figure 2.7. Home page

When you click the «Add Delivery date» button (Figure 2.8), a form appears that contains a product title that cannot be edited. The form also contains the «Consumption per day» field, where you can change the value, and the «Date» field, where you can select the delivery date of the item. After clicking the «Add» button, the corresponding record is added to the database. This action is repeated for each item. The result can be seen in Figure 2.9.

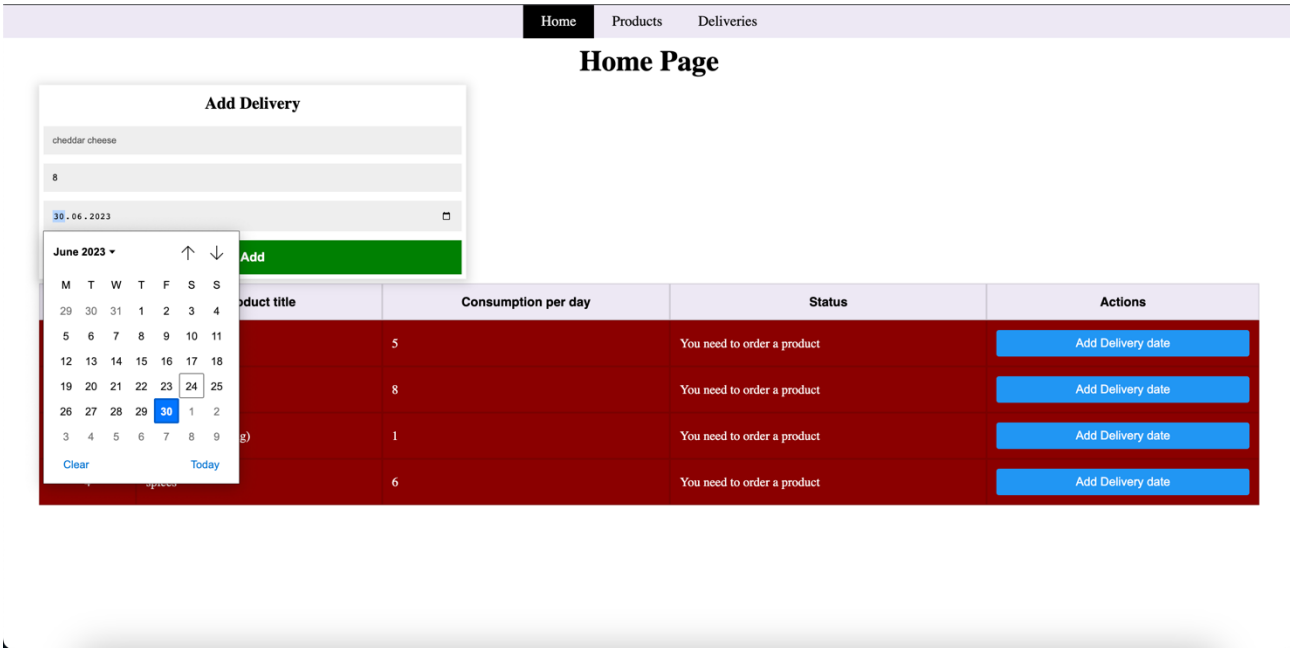

Figure 2.8. Home page with form

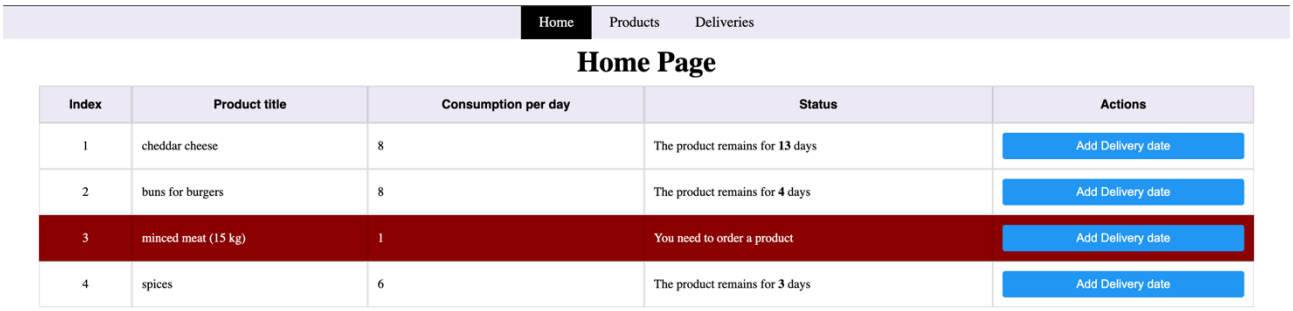

Figure 2.9. Home page with form

Figure 2.9 shows all the items. The «Status» field shows how many days of product are left, and visually highlights the item for which you need to place an order now.

The «Deliveries» page (Figure 2.10) has the least functionality, but it shows a list of all delivery orders with the corresponding dates.

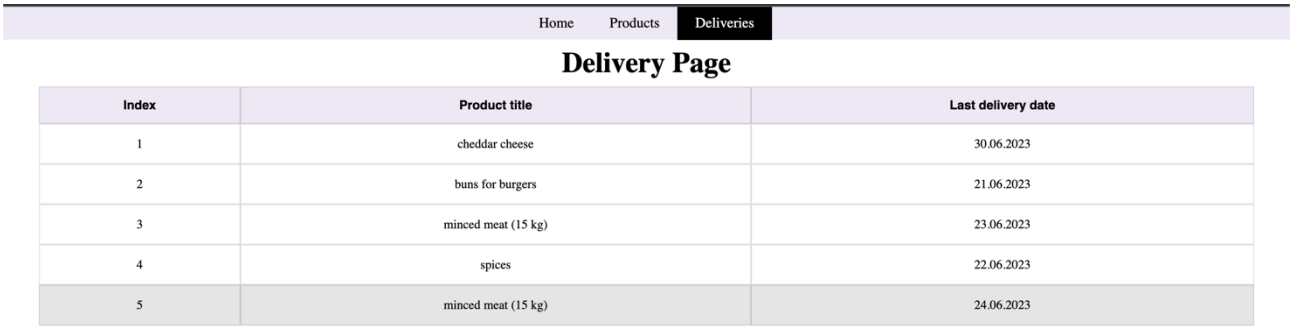

Figure 2.10. Delivery page

The backend of this web application is written in node.js using the express.js framework.

The frontend is developed using react.js, which makes it possible to add, modify, and view information quickly without overloading pages.

This project used a non-relational database (NoSQL) MongoDB, which stores data in the form of documents in BSON (Binary JSON) format.

There are two collections in this database: "Delivery" and «Product» (Figure 2.11).

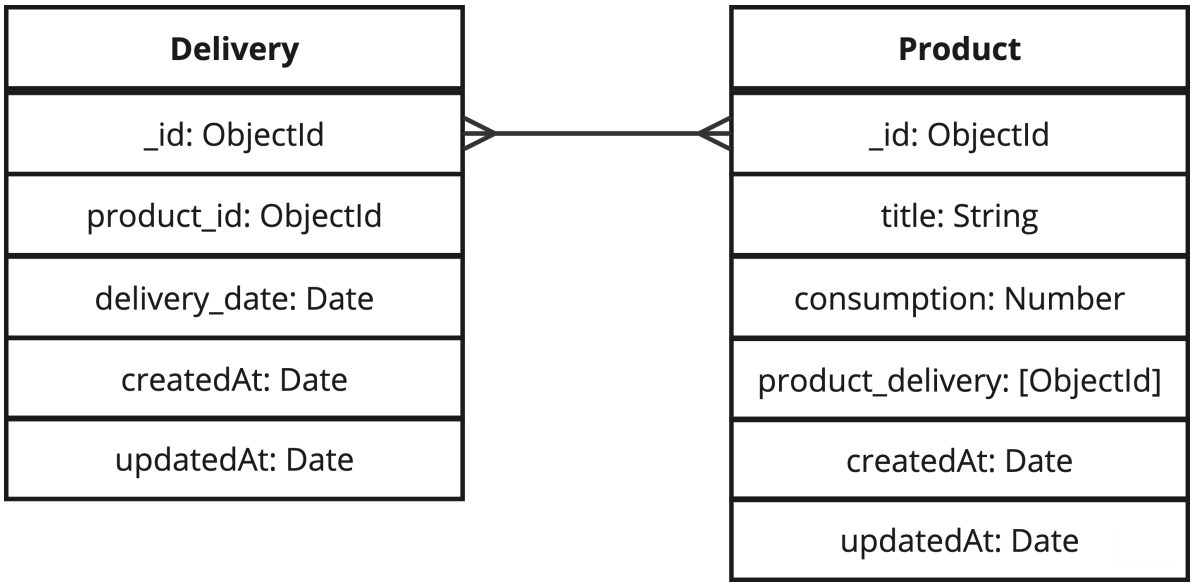

Figure 2.11. Database

The Delivery collection contains the following fields:

- **_id**: Unique identifier of the delivery (ObjectId).
- **product_id**: The product identifier associated with this delivery (ObjectId), referenced by the «Product» collection.
- **delivery_date**: Date of delivery (Date).
- **createdAt**: Date and time the record was created (automatically generated by Mongoose).
- **updatedAt**: Date and time the record was last updated (automatically generated by Mongoose).

The Product collection contains the following fields:

- **_id**: The unique identifier of the product (ObjectId).
- **title**: The name of the product (String).
- **consumption**: The amount of consumption of the product (Number).
- **product_delivery**: An array of delivery IDs associated with this product (Array of ObjectId), referenced by the «Delivery» collection.
- **createdAt**: Date and time the record was created (automatically generated by Mongoose).
- **updatedAt**: Date and time the record was last updated (automatically generated by Mongoose).

Relationships between collections:

- The «Delivery» collection has a many-to-one relationship with the «Product» collection using the «product_id» field.
- The «Product» collection has a one-to-many relationship with the «Delivery» collection using the «product_delivery» field.

We created a web application that includes several pages to help manage products and delivery orders. The application's interface is simple and user-friendly, providing ease of use.

The application provides a wide range of functionality that allows you to effectively

organise production processes and control the delivery needs of products. It allows you to add new items, edit and delete existing ones, and track delivery dates.

Thanks to the web application, users are provided with a convenient way to manage products and delivery orders. They can effectively plan and organise their work, ensuring timely delivery of products according to their needs.

2.4. Evaluation of expected effect from implementing the automation system

Methods of calculating profitability vary depending on the industry, enterprise and product type. The introduction of automation has an economic effect, but its main advantage is cost reduction, as automation itself is not a source of profit. The introduction of automation tools leads to a reduction in the use of various enterprise resources, by increasing management efficiency and reducing labour costs associated with the implementation of management processes. [21]

Figure 2.12 shows the price list of the alternative to the developed system.

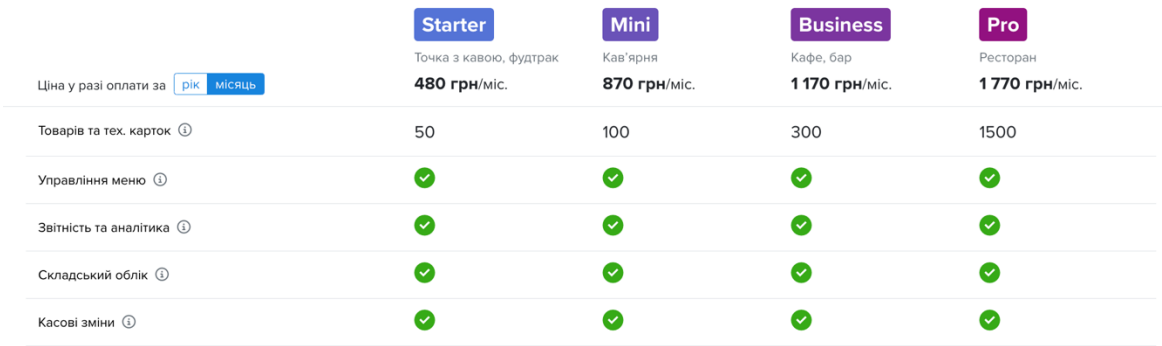

Figure 2.12. Price page joinposter

When implementing an automation system for managing products and delivery orders, a significant positive impact on the efficiency and productivity of the enterprise is expected.

To estimate the savings gained from developing this web application, it is necessary to calculate the capital costs. Formula 3.1 of the capital costs includes the costs of software and hardware, design, programming, implementation, and debugging of the system. [21]

$$К = К_1 + К_2 + К_3 + К_4 + К_5 + К_6 \quad (3.1)$$

Where:

$К_1$ - system design costs;

$К_2$ - system programming costs;

$К_3$ - system implementation costs;

$К_4$ - costs of debugging and testing the system;

$К_5$ - software costs;

$К_6$ - hardware costs; The salary of a programmer reflects the main costs. To determine this amount, you need to analyses the working hours and multiply them by the hourly wage rate.

- time for analysis of the design of the automated system - 10 hours;
- the cost of developing an automated system - 30 hours;
- the cost of testing the system - 10 hours;

Working time costs are 50 hours.

After analysing the resources, it is established that the minimum salary of a programmer who can perform this technical task is approximately UAH 74,000. Given a 5-day working week and 8 working hours per day, the hourly wage for developing a web application will be 1850 UAH/hour.

Given the above data, you can now move on to the next step. The cost of hardware depends on the user's needs and needs to be further determined, but the average price for a VPS hosting subscription at https://www.ukraine.com.ua/uk/vps/ is UAH 5292 per year. Registration of the NAME_COMPANY.com.ua domain costs 480 UAH.

$$К = 50 * 1850 + 5292 + 480 = 98\,272 \text{ (UAH)}$$

It should be noted that paid services have advanced functionality and additional features, but this is not necessary for ordinary users. As a result, almost UAH 99,000 was saved on development, taking this fact into account.

CONCLUSION

In the process of developing a system for automated monitoring of the procurement process using digital technologies and analysing the results of previous procurements, a detailed analysis of current approaches to monitoring the procurement process was carried out. A review of existing monitoring systems showed that many of them are used by government agencies and businesses to control and effectively manage procurement procedures.

The use of digital technologies in procurement monitoring was also investigated. It was found that digital technologies, process automation and data analytics can significantly improve the efficiency and accuracy of procurement monitoring.

In the process of developing the system, the requirements for the monitoring system were identified and the terms of reference were developed. We also selected the necessary technologies to implement the system. The result is a developed system for automated monitoring of the procurement process.

The first page of the developed web application, labelled «Production», displays a list of all available items in the database along with their quantity. Each item can be deleted or edited using the «Delete» and «Edit» buttons, respectively.

The second page, «Home», offers a view of the items that need to be ordered. These items can be visually highlighted in red for quick distinction. For each item, the functionality of adding a delivery date and editing the consumption of products per day is available. After making changes, the order is saved in the database.

The Home page also provides information on how many days are left for the products, and the red highlighting indicates those items for which an order must be placed immediately.

The last page, «Deliveries», simply displays a list of delivery orders with their respective dates.

Overall, the development of a web-based automated procurement monitoring system application provides a convenient and easy-to-use interface for managing products, delivery orders, and tracking delivery dates.

Assessing cost-effectiveness is one of the key components of various automated

innovations. By calculating these indicators, we can determine whether it is reasonable to spend resources on automating business processes and whether it can lead to losses. In the section that follows, it is described in detail that the implementation of the system will save approximately UAH 99,000.

Therefore, we can assume that the goal of the qualification work has been achieved and the tasks have been fully completed.

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APPENDIXES

Appendix A
(mandatory)

ABSTRACT OF QUALIFICATION WORK

SUMMARY

Havrylenko Mariia Oleksandrivna «Developing a System for Automated Monitoring of the Procurement Process Using Digital Technologies and Analyzing the Results of Previous Procurements» - Bachelor's thesis. Sumy State University, Sumy, 2023.

The main purpose of the study is to develop a system for automated monitoring of the procurement process. The paper investigates the essence of monitoring the procurement process, analyzes the activities of the enterprise, and develops an automatic procurement monitoring system. The requirements for the system were presented and the technologies for developing the service were selected. A detailed description of the structure and functionality of the service was provided.

The efficiency of the developed analytical service was evaluated.

Keywords: automation, procurement, enterprise, automation of the procurement process.

АНОТАЦІЯ

Гавриленко Марія Олександрівна «Розробка системи автоматизованого моніторингу процесу закупівлі з використанням цифрових технологій та аналіз результатів попередніх закупівель» – Кваліфікаційна робота бакалавра. Сумський державний університет, Суми, 2023 р.

Основною метою дослідження є розробка системи автоматизованого моніторингу процесу закупівлі. У роботі досліджено сутність моніторингу процесу закупівель, проведений аналіз діяльності підприємства, розроблена автоматична система моніторингу закупівель. Були наведені вимоги до системи та був здійснений вибір технологій для розробки сервісу. Був наведений детальний опис структури та функціоналу сервісу.

Проведена оцінка ефективності розробленого аналітичного сервісу.

Ключові слова: автоматизація, закупівля, підприємство, автоматизація процесу закупівель.

Appendix B

(informational)

Table 1. Short analysis of my program by Excel tables

products:	**delivery date:**	**delivery date:**	**delivery date:**	**consumption (days)**	**delivery**
cheddar cheese	31.05	05.06	10.06	5	1/5 days
buns for burgers	29.05	06.06	14.06	8	1/8 days
minced meat (15 kg)	06.06	07.06	08.06	1	every day
spices	02.06	08.06	14.06	6	1/6 days

Listing B.1 - code file Model table «Delivery» of the database

models > Delivery.js > ...

```
1   import mongoose from 'mongoose'
2
3   const DeliverySchema = new mongoose.Schema({
4     product_id: {
5       type: mongoose.Schema.Types.ObjectId,
6       ref: 'Product',
7       required: true
8     },
9     delivery_date: {
10      type: Date,
11      required: [true, 'Fill in consumption'],
12    },
13  }, {
14    timestamps: true
15  })
16
17
18  export default mongoose.model('Delivery', DeliverySchema)
19
```

Listing B.2 - code file Model table «Product» of the database

models > JS Product.js > ...

```
1   import mongoose from 'mongoose'
2
3   const ProductSchema = new mongoose.Schema({
4     title: {
5       type: String,
6       required: [true, 'Fill in the name of the product'],
7       trim: true,
8     },
9     consumption: {
10      type: Number,
11      required: [true, 'Fill in consumption'],
12    },
13    product_delivery: [{
14      type: mongoose.Schema.Types.ObjectId,
15      ref: 'Delivery',
16    }],
17  }, {
18    timestamps: true
19  })
20
21
22  export default mongoose.model('Product', ProductSchema)
23
```

Listing B.3 - code file deliveryController.js

controllers > deliveryController.js > ...

```
1   import Delivery from '../models/Delivery.js';
2   import Product from '../models/Product.js';
3   import { StatusCodes } from 'http-status-codes';
4   import { BadRequestError, NotFoundError } from "../errors/index.js";
5
6   const createDelivery = async (req, res) => {
7     const { product_id, delivery_date, consumption } = req.body;
8     if (!product_id || !delivery_date || !consumption) {
9       throw new BadRequestError('Fill in all fields');
10    }
11    const formattedDeliveryDate = new Date(delivery_date.split('.').reverse().join('-'));
12
13    const product = await Delivery.create({ product_id, delivery_date: formattedDeliveryDate });
14
15    await Product.updateOne(
16      { _id: product_id },
17      { $addToSet: { product_delivery: product._id } }
18    );
19    await Product.findOneAndUpdate(
20      { _id: product_id },
21      { consumption },
22      { new: true, runValidators: true }
23    );
24    res.status(StatusCodes.CREATED).json({ product });
25  };
26
27  const getAllDeliveries = async (req, res) => {
28    const deliveries = await Delivery.find().populate('product_id', 'title consumption');
29    res.status(StatusCodes.OK).json({
30      deliveries
31    });
32  };
33
34  export { createDelivery, getAllDeliveries };
```

Listing B.4 - code file productController.js (Parth 1)

controllers > productController.js > getAllProducts

```
1   import Product from '../models/Product.js';
2   import { StatusCodes } from 'http-status-codes';
3   import { BadRequestError, NotFoundError } from "../errors/index.js";
4
5   const createProduct = async (req, res) => {
6     const { title, consumption } = req.body;
7     console.log(!title, !consumption)
8     if (!title || !consumption) {
9       throw new BadRequestError('Fill in all fields');
10    }
11    const product = await Product.create({ title, consumption });
12    res.status(StatusCodes.CREATED).json({ product });
13  };
14
15  const getAllProducts = async (req, res) => {
16    let totalProducts = await Product.countDocuments();
17    const products = await Product.find().sort({ "createdAt": -1 })
18    res.status(StatusCodes.OK).json({
19      products,
20      totalProducts,
21    });
22  };
23
24  const updateProduct = async (req, res) => {
25    const { id: productId } = req.params;
26    const { title, consumption } = req.body;
27    if (!title || !consumption) {
28      throw new BadRequestError('Fill in all fields');
29    }
30    const product = await Product.findOne({ _id: productId });
31    if (!product) {
32      throw new NotFoundError(`No product with id exists :${productId}`);
33    }
34    const updatedProduct = await Product.findOneAndUpdate({ _id: productId }, req.body, {
35      new: true,
36      runValidators: true,
37    });
38    res.status(StatusCodes.OK).json({ updatedProduct });
39  };
```

Listing B.5 - code file productController.js (Parth 2)

```
40
41  const deleteProduct = async (req, res) => {
42    const { id: productId } = req.params;
43    const product = await Product.findOne({ _id: productId });
44    if (!product) {
45      throw new NotFoundError(`No product with id exists: ${productId}`);
46    }
47    await product.deleteOne();
48    res.status(StatusCodes.OK).json({ msg: 'Success! Information about the threat has been removed' });
49  };
50
51  const getAllProductsDeliveries = async (req, res) => {
52    const products = await Product.find().populate({
53      path: 'product_delivery',
54      select: 'delivery_date',
55      options: { sort: { delivery_date: -1 } }
56    });
57    const updatedProducts = products.map(product => {
58      const nextDeliveryDate = product.product_delivery[0]?.delivery_date;
59      const consumption = product.consumption;
60
61      let nextUpdateProduct = null;
62      if (nextDeliveryDate) {
63        const date = new Date(nextDeliveryDate);
64        date.setDate(date.getDate() + consumption);
65        nextUpdateProduct = date.toISOString();
66      }
67      let daysDiff = 0;
68      if (nextUpdateProduct !== null) {
69        const currentDate = new Date();
70        const date = new Date(nextUpdateProduct);
71        const millisecondsDiff = date - currentDate;
72        daysDiff = Math.round(millisecondsDiff / (1000 * 60 * 60 * 24));
73      }
74
```

Listing B.5 - code file productController.js (Parth 3)

```
75        return {
76          _id: product._id,
77          title: product.title,
78          consumption: product.consumption,
79          isRequire: daysDiff <= 1 ? true : false,
80          status: daysDiff,
81          product_delivery: product.product_delivery,
82          createdAt: product.createdAt,
83          updatedAt: product.updatedAt,
84          __v: product.__v
85        };
86      });
87      res.status(StatusCodes.OK).json({
88        products: updatedProducts
89      });
90    }
91
92    export { createProduct, deleteProduct, getAllProducts, updateProduct, getAllProductsDeliveries };
93
```

Listing B.6 - code file server.js

server.js > ...

```
import "dotenv/config"
import express from "express"
import cors from "cors"

const app = express();

import connectDB from "./db/connect.js";

// routers
import deliveriesRoutes from "./routes/deliveriesRoutes.js"
import productsRoutes from "./routes/productsRoutes.js"

// middleware
import notFoundMiddleware from './middleware/not-found.js';
import errorHandlerMiddleware from './middleware/error-handler.js';

app.use(express.json());
app.use(cors({
  credentials: true,
  origin: process.env.CLIENT_URL
}))

app.use('/api/v1/deliveries', deliveriesRoutes)
app.use('/api/v1/products', productsRoutes)

app.use(notFoundMiddleware);
app.use(errorHandlerMiddleware);

const port = process.env.PORT || 8001

const start = async () => {
  try {
    await connectDB(process.env.MONGO_URL);
    app.listen(port, () => {
      console.log(`Server is listening on port ${port}`);
    })
  } catch (error) {
    console.log(error)
  }

}

start();
```

Listing B.6 - project structure