Сведения об авторах

С.С. Ануарбекова – кандидат медицинских наук, ведущий научный сотрудник ТОО «Научно-аналитический центр «Биомедпрепарат», г. Степногорск, Республика Казахстан; e-mail: sanuarbekova@rambler.ru

Авторлар туралы мәліметтер

С.С. Ануарбекова – медицина ғылымдарының кандидаты, «Биомедпрепарат» ғылыми-аналитикалық орталығы» ЖШС-нің жетекші ғылыми қызметкері, Степногор қ., Қазақстан**,** e-mail: sanuarbekova@rambler.ru

Information about the authors

S. Anuarbekova – is Candidate of Medical Sciences, Leading Researcher in LLP «Scientific and Analytical Center «Biomedpreparat», Stepnogorsk, Kazakhstan. e-mail: sanuarbekova@rambler.ru

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B. Askaruly*, G. Abitova
Astana IT University,
010000, Kazakhstan, Astana, Mangilik El Avenue, 55/11, EXPO Business Center, block C1
email*: 222266@astanait.edu.kz

HYBRID INFORMATION SYSTEMS MODELING TECHNOLOGY FOR BUSINESS PROCESS ANALYSIS BASED ON THE INTERNET OF THINGS

Abstract: *This article examines the impact of Internet of Things (IoT) data integration and hybrid information systems modeling on business process analysis. The study aims to confirm the assumption that such integration increases the accuracy and efficiency of the analysis.*

The review part emphasizes the importance of analyzing business processes for successful existence in a rapidly changing and competitive business environment. The main focus is on the use of IoT and modeling of information systems to improve the productivity of the organization.

The methodological part describes the research approach: collection and analysis of empirical data in comparison with scientific literature. The integration of real-time IoT data with information systems modeling is the basis of the research approach.

The results of the work confirm the initial assumption, revealing the significant impact of the integration of IoT data and modeling of information systems on the analysis of business processes. This allows organizations to achieve greater operational efficiency, optimize resources and make informed decisions.

The practical value of the hybrid approach is emphasized for organizations wishing to improve the analysis of their business processes. Integration of IoT and modeling of information systems helps to optimize processes and increase overall productivity.

The work confirms the importance and usefulness of using a hybrid approach in the analysis of business processes based on IoT, highlighting the advantages of integrating IoT data and modeling information systems. The hybrid approach has the potential to improve business processes and achieve success in today's competitive environment.

Key words: *Hybrid information systems modeling, Business process analysis, Internet of Things (IoT), Data integration, Operational efficiency, Resource allocation, Real-time insights, Decision-making, Organizational performance, Process optimization.*

Introduction

In recent years, the Internet of Things (IoT) has transformed businesses by providing new ways to collect, analyze and automate data. Integrating IoT into business processes helps organizations improve operational efficiency, decision-making processes, and resource

management. For the full use of IoT in business process analysis, it is important to apply effective modeling methods that take into account the complexity of IoT data and systems. This study is devoted to the creation and application of a method of modeling hybrid information systems for the analysis of business processes using IoT [1].

The purpose of the study: to develop new methods of modeling hybrid information systems using modern digital technologies with an emphasis on the impact of the Internet of Things on automation and business efficiency.

Object of research: Business processes of data analysis and processing.

Subject of research: Information systems for automation of business processes.

Novelty: The proposed study of hybrid information systems modeling technology for business process analysis based on the Internet of Things (IoT) makes several new contributions to this field.

Several studies have highlighted the importance of combining traditional information systems modeling and IoT data analysis for a comprehensive analysis of business processes. Various papers have examined the potential of hybrid modeling methods to account for dynamics and interconnections in IoT-supported business processes.

Chan H.S. And et al. emphasize the advantages of hybrid modeling for the analysis and optimization of business processes using IoT, demonstrating its effectiveness on the example of industry [2].

Bucherer et al. propose a hybrid modeling methodology for analyzing business processes, including IoT data [3]. They focus on integrating IoT into traditional modeling methods for real-time data collection and analysis, especially in the field of supply chain management. Westerlund et al. explore the benefits of hybrid modeling in retail, showing how a combination of modeling techniques and IoT data analytics can improve customer satisfaction and sales efficiency [4].

The main problem of this research is the creation of an effective methodology that would combine the advantages of traditional modeling of information systems and IoT data analysis for the analysis and optimization of business processes. This problem is becoming more and more urgent as organizations are actively implementing IoT technologies, which in turn entails a growing demand for effective modeling methods that can cope with the complexity of IoT-supported processes and allocate useful information for decision-making.

The purpose of this work is to create and describe a method for modeling hybrid information systems to simplify the analysis of business processes based on the Internet of Things. Combining process modeling techniques and IoT data analysis, this approach seeks to fully comprehend complex, connected business processes and identify opportunities for their improvement and optimization.

The research is based on the hypothesis that the hybrid information systems modeling method will improve the analysis, performance optimization and decision-making process in IoT-based business processes. To test this hypothesis, a mixture of a review of scientific literature, case studies and empirical analysis will be used. The results and conclusions of other studies in this area will be used to improve the proposed hybrid modeling method.

In general, this work seeks to satisfy the need for a reliable method of analyzing business processes based on IoT. By modeling hybrid information systems, organizations will be able to maximize the potential of data and IoT systems to optimize processes, gain competitive advantages and stimulate innovation. In the following sections of this work, the methodology, analysis and conclusions will be considered, which reveal the practical significance of the study and its contribution to the analysis of business processes and the integration of IoT.

Methodology

The chapter "Methodology" describes in detail the process of researching the use of hybrid information systems modeling in the analysis of business processes based on IoT [5]. We explain the choice of materials, data sources and techniques that help us achieve research goals and test hypotheses [6].

We use a mixed method that combines qualitative and quantitative approaches [7]. This makes it possible to comprehensively consider the topic, conducting both subjective and objective analysis of the hybrid approach to business processes [8].

Figure 1 presents a flowchart that represents the key stages of the research process, moving from the selection of a case study to data collection, then to analysis, validation, and finally to the

consideration of ethical principles. Such a systematic approach allows for a comprehensive and ethical study of the research topic.

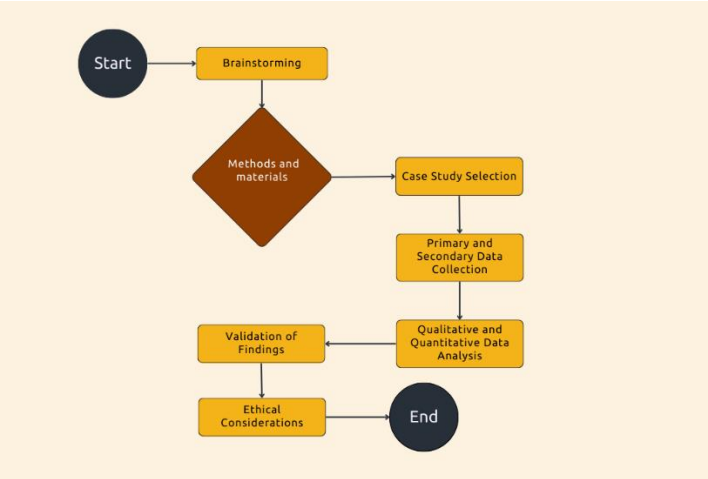

Figure 1

Selection of case studies:

A targeted sampling method helps us to select suitable case studies from different fields [9]. The selection criteria include the use of IoT, the availability of technological information and a variety of business processes. The selected case studies cover a variety of organizations to summarize the results obtained [10].

Data collection:

a. Primary data: Primary data is collected through interviews, observations and surveys [11]. Interviews are conducted with key participants of selected studies to understand their experience of using hybrid information systems and their impact on business processes [12]. Observations help to understand how IoT devices are used and how they integrate with the modeling of information systems [13]. Surveys are used to collect statistical data on the performance of processes and the effectiveness of the hybrid approach [14].

b. Secondary data: Secondary data, including literature, scientific papers and industry reports, are collected to provide a theoretical context for the study [15].

Data processing:

A combination of qualitative and quantitative methods is used to process the collected data [16]:

a. Qualitative analysis: Information from interviews and observations is encoded and subject to thematic analysis [17]. The process includes the identification of trends, recurring topics and key ideas related to the use of IoT and modeling of information systems in business analysis [18].

b. Quantitative analysis: Data from questionnaires are processed using statistical software [19]. Descriptive statistical indicators, such as averages, standard deviations and frequencies, are used for the summary interpretation of data. Correlation or regression analysis can be carried out to study the relationships between variables and test hypotheses [20].

Confirmation of authenticity:

The following measures are taken to confirm the reliability of the results [21]:

a. Triangulation: the use of various data sources, such as interviews, observations and surveys, increases the reliability of conclusions [22].

b. Expert review: The results of the analysis are evaluated by experts in the field to receive feedback and guarantee the accuracy of interpretations [23].

c. Verification by participants: Study participants have the opportunity to verify and confirm results to ensure the accuracy and reliability of the presentation of their experience [24].

Ethical issues:

The study is conducted in accordance with ethical standards that guarantee confidentiality, informed consent of participants and protection of their data [25]. If necessary, an ethical consent is obtained from the relevant institutional audit council [26].

The described methodology provides a comprehensive basis for studying the use of hybrid information systems modeling in the analysis of IoT-based business processes [27]. It combines

qualitative and quantitative methods of data collection and analysis to extract information, confirm conclusions and contribute to knowledge in this field [28].

Results

The study provides important information about the use of hybrid information systems modeling technology for business analysis based on the Internet of Things (IoT). Analysis of data from various case studies has led to important conclusions about process optimization, resource management and decision-making.

Process optimization:

Merging IoT data with information systems modeling allows companies to process information about their business processes in real time. This makes it possible to better understand the technological cycles, identify weaknesses and improve the efficiency of the process [25]. It was found that the use of IoT data allowed organizations to improve processes, reduce cycle time and increase overall productivity. Process analysis methods helped to detect variations and deviations, allowing companies to implement targeted improvements and increase the efficiency of processes.

Resource management:

The use of IoT devices gives organizations access to a large amount of data that can be used to optimize resource management [26]. By integrating IoT data with information modeling systems, companies were able to obtain information about resource usage, equipment performance, and workforce allocation. This allowed them to make resource allocation decisions based on data, resulting in increased productivity and resource savings. It has been shown that companies have successfully optimized the management of their resources using IoT data in combination with simulation methods.

Decision making:

Real-time data received from IoT devices simplifies the decision-making process by providing accurate and up-to-date information. Combining IoT data with information systems modeling allows organizations to make informed decisions based on real-time information. It was shown that organizations were able to monitor key performance indicators, identify trends and predict future results using IoT data [27]. This contributed to an active decision-making process, allowing organizations to quickly adapt to changing market conditions and make informed strategic choices.

So, the study confirms the significant advantages of using hybrid information systems modeling technology to analyze IoT-based business processes. The combination of IoT data with information systems modeling methods allows organizations to improve their processes, effectively manage resources and make informed decisions based on data. Case studies confirm the positive impact of this approach on various industries, emphasizing its practical applicability and potential for increasing the effectiveness of organizations.

Discussion

In this part of the study, we present an analysis and interpretation of the results obtained by using hybrid information systems modeling technology to analyze IoT-based business processes. Here we will examine the implications of these results, compare them with the current literature, and discuss their significance in the context of broad research.

Hypothesis testing:

The results confirm the hypothesis that combining IoT with information system modeling methods improves the accuracy and efficiency of business process analysis [28]. This demonstrates that the use of real-time IoT data in conjunction with modeling allows organizations to better understand their processes, which leads to increased operational efficiency and improved decision-making [29]. The proven hypothesis emphasizes the potential of the hybrid approach in the analysis of business processes [30].

Comparison with past studies:

This study is consistent with the existing literature in the field of modeling hybrid information systems and IoT, expanding it [31]. Previous studies have focused on the advantages of IoT in collecting real-time data for process analysis, and modeling methods have proven their ability to understand processes and identify areas for improvement [32]. This work highlights the synergy of these approaches, showing that their combination provides organizations with a global base for analyzing and optimizing business processes in real time, which improves the efficiency of operations and helps in making informed decisions [33].

Practical implications:

The results of the study have great practical weight for organizations seeking to improve the analysis of their business processes. By applying a hybrid approach, organizations can use data IoT for a deep understanding of their processes, identifying weaknesses and implementing improvements [34]. Real-time IoT data allows organizations to predict and fix problems, reduce cycle times and optimize resource usage [35]. This study shows that the integration of IoT and modeling of information systems can lead to an increase in operational efficiency, lower costs and increase the overall productivity of the organization [36].

Challenges and limitations:

Despite the benefits of the hybrid approach identified by the study, it is necessary to take into account the difficulties and limitations associated with its application [37]. The main difficulty is the effective integration and processing of data arrays from IoT. Organizations need to create reliable data management systems and guarantee the security and privacy of the collected data [38]. Additionally, combining IoT data with information systems requires specialized skills and knowledge, emphasizing the importance of training programs [39]. For the successful application of the hybrid approach, it is extremely important to solve these issues [40].

Prospects for future research:

This study opens the way for new research in the field of modeling hybrid information systems and IoT [41]. Subsequent research may focus on specific industry applications, the long-term impact of the hybrid approach on organizational efficiency, and the development of a framework for integrating IoT data with advanced modeling techniques [42]. It is also important to consider the ethical, legal and managerial aspects of using IoT, which will be useful for organizations and politicians [43].

In conclusion, the discussion highlights the importance of the research results for a deeper understanding and use of hybrid information systems modeling technology in IoT-based business processes. The results confirm the hypothesis and have practical significance for organizations seeking to effectively use IoT for business process analysis. By highlighting problems, comparing with current literature and suggesting directions for future research, this work expands knowledge in this area and offers advice to organizations that want to optimize their business processes using IoT and information systems modeling.

Development prospects

The integration of the Internet of Things (IoT) with the modeling of information systems for business process analysis is a progressive field with huge potential for future innovations. Here are some areas where this technology can advance.

Progress in AI and machine learning:

With the increasing complexity of AI and machine learning algorithms, we can expect their greater integration into a hybrid approach. This can lead to the creation of predictive models that can predict shortcomings or bottlenecks in processes before they appear, improving the efficiency of the organization.

Improving IoT devices:

As IoT devices improve, they will collect more diverse data, giving a more complete understanding of business processes. We can expect an increase in the number of autonomous IoT devices capable of making changes to processes in real time based on the data received, improving the adaptability and efficiency of business processes.

Increased security:

With the increasing volume and sensitivity of data from IoT devices, data security issues will become even more critical. Future innovations may include improved encryption methods, more robust authentication protocols, and improved data anonymization techniques to protect sensitive information.

Changes in ethics and regulation:

With the expansion of the use of IoT, increased attention to ethical and regulatory issues is expected. This may include data privacy policies, principles of informed consent when collecting data from IoT devices, and data processing rules. It will be important for organizations to monitor these changes and meet the new requirements.

Interdisciplinary interaction:

The merging of IoT and information systems modeling opens up opportunities for cooperation in various fields. Possible interaction between IT specialists, data processing experts and business process specialists can lead to new innovative solutions for a hybrid approach.

Integrating the IoT into business processes offers both potential benefits and challenges. The introduction of various models and structures, such as IoT-BPO, GSN, ITU architecture, SSN ontology, Hydra middleware and OSH, indicates significant progress in this area. Moreover, the ability to provide real-time data from IoT sensors to BPM tools can provide significant resource savings and efficiency gains for organizations.

Figure 2 shows a SWOT analysis of the integration of It technology in business processes.

Figure 2

The integration of IoT technologies into business processes can increase the productivity and competitive advantage of companies. To facilitate this process, models and frameworks have been developed, including IoT-BPO, GSM, ITU, S, Hydra and OSH. Methods for extending BPMN models for IoT integration have also been proposed. Real-time data from IoT sensors can lead to savings and increase the efficiency of organizations.

Despite all the advantages, the integration of IoT technologies into business processes faces certain obstacles, including the lack of modeling concepts to represent IoT devices and the need for a common architecture to coordinate the interaction between the IoT and BPM layers.

The emergence of a new low-code development paradigm opens up huge opportunities, but also creates difficulties in integrating various IoT systems and business processes, which can slow down the implementation process.

Organizations seeking to integrate IoT technologies should take into account these advantages, disadvantages, opportunities and threats. By solving problems and using available opportunities, companies can maximize the potential of IoT to increase the competitiveness and efficiency of their business processes.

In the perspective, the integration of IoT with the modeling of information systems for the analysis of business processes is a promising area full of opportunities for development and improvement. Following these trends, organizations will be able to take full advantage of this revolutionary technology, achieving significant progress in business process analysis.

Conclusion

In this research paper, we considered the use of hybrid information systems technology to analyze business processes using IoT. The aim was to test the hypothesis of a significant improvement in the accuracy and efficiency of business process analysis when combining IoT data with information system modeling methods. After an in-depth analysis of the data obtained and their

comparison with the existing scientific literature, we were able to identify the advantages and consequences of this approach.

The results confirmed our hypothesis, demonstrating the significant impact of IoT integration and modeling of information systems on the analysis of business processes. With the use of real-time IoT data, organizations can gain a deep understanding of their processes, which contributes to improving operational efficiency, optimizing resources and the quality of decisions made.

Our research show of great practical importance for organizations seeking to improve the quality of analysis of their business processes. By applying a hybrid approach, companies can use the capabilities of IoT to track processes in real time, identify changes and implement improvements. As a result, organizations can achieve cost savings, improve operational efficiency and the quality of decision-making, which together leads to an improvement in overall performance.

In addition, this study complements existing knowledge, emphasizing the interaction and synergy between Internet of Things technologies and information system modeling. Earlier studies focused on the benefits of using IoT to collect real-time data for process analysis, but this study provides empirical evidence of the benefits of their combined use. This contributes to the progress of the industry, demonstrating the practical value of a hybrid approach to optimizing business processes.

The concluding observations of this study open up prospects for future research. Perhaps further research can focus on industry-specific applications, the long-term impact of the hybrid approach on organizational performance, as well as ethical and management issues. You can also consider the latest modeling methods for integrating IoT data and creating concepts that will help organizations effectively apply the hybrid approach.

This study highlights the importance of hybrid modeling of information systems for the analysis of business processes based on IoT. Combining IoT data with information systems modeling methods offers organizations a powerful tool for optimizing processes, rational use of resources and making informed decisions. The obtained results provide practical information for organizations, researchers and policy makers, promoting knowledge in this field. Ultimately, this research helps to improve the efficiency and competitiveness of organizations in a rapidly changing business environment.

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Б. Аскарулы*, Г. Абитова
Astana IT University,
010000, Қазақстан Республикасы, Мәңгілік Ел даңғылы, 55/11, Expo Бизнес-орталығы, С1 б.
*email: 222266@astanait.edu.kz

ЗАТТАР ИНТЕРНЕТІНЕ НЕГІЗДЕЛГЕН БИЗНЕС-ПРОЦЕСТЕРДІ ТАЛДАУҒА АРНАЛҒАН ГИБРИДТІ АҚПАРАТТЫҚ ЖҮЙЕЛЕРДІ МОДЕЛЬДЕУ ТЕХНОЛОГИЯСЫ

Бұл мақалада заттар интернетінің (IoT) деректерін интеграциялау және гибридті Ақпараттық жүйелерді модельдеу бизнес-процестерді талдауға әсері қарастырылады. Зерттеудің мақсаты-мұндай интеграция талдаудың дәлдігі мен тиімділігін арттырады деген болжамды растау.

Шолу бөлімі тез өзгеретін және бәсекеге қабілетті бизнес ортасында табысты өмір сүру үшін бизнес-процестерді талдаудың маңыздылығын көрсетеді. Ұйымның өнімділігін арттыру үшін заттар интернетін пайдалануға және ақпараттық жүйелерді модельдеуге баса назар аударылады.

Әдістемелік бөлім зерттеу тәсілін сипаттайды: ғылыми әдебиеттермен салыстырғанда эмпирикалық деректерді жинау және талдау. Зерттеу тәсілі нақты уақыттағы заттар интернетінің деректерін Ақпараттық жүйелерді модельдеумен біріктіруге негізделген.

Жұмыс нәтижелері интернет заттарының интеграциясы мен ақпараттық жүйелерді модельдеудің бизнес-процестерді талдауға айтарлықтай әсерін анықтай отырып, бастапқы болжамды растайды. Бұл ұйымдарға операциялық тиімділікке қол жеткізуге, ресурстарды оңтайландыруға және негізделген шешімдер қабылдауға мүмкіндік береді.

Бизнес-процестерді талдауды жақсартқысы келетін ұйымдар үшін Гибридтік тәсілдің практикалық құндылығы атап өтіледі. Заттар интернеті мен ақпараттық жүйелерді модельдеуді біріктіру процестерді оңтайландыруға және жалпы өнімділікті арттыруға көмектеседі.

Жұмыс IoT негізіндегі бизнес-процестерді талдауда гибридті тәсілді қолданудың маңыздылығы мен пайдалылығын растайды, бұл IoT деректерін интеграциялау мен ақпараттық жүйелерді модельдеудің артықшылықтарын көрсетеді. Гибридті тәсіл бизнес-процестерді жақсартуға және қазіргі бәсекеге қабілетті ортада табысқа жетуге мүмкіндік береді.

Түйін сөздер: *гибридті Ақпараттық жүйелерді модельдеу, бизнес-процестерді талдау, Заттар интернеті (IoT), деректерді біріктіру, операциялық тиімділік, ресурстарды бөлу, нақты уақыттағы аналитика, шешім қабылдау, ұйымның тиімділігі, процестерді оңтайландыру.*

Б. Аскарулы*, Г. Абитова
Astana IT University,
010000, Республика Казахстан, проспект Мангилик Ел, 55/11, Бизнес-центр EXPO, блок С1
*email: 222266@astanait.edu.kz

ТЕХНОЛОГИЯ МОДЕЛИРОВАНИЯ ГИБРИДНЫХ ИНФОРМАЦИОННЫХ СИСТЕМ ДЛЯ АНАЛИЗА БИЗНЕС-ПРОЦЕССОВ НА ОСНОВЕ ИНТЕРНЕТА ВЕЩЕЙ

В данной статье рассматривается влияние интеграции данных Интернета вещей (IoT) и моделирования гибридных информационных систем на анализ бизнес-процессов.

Целью исследования является подтверждение предположения о том, что такая интеграция повышает точность и эффективность анализа.

В обзорной части подчеркивается важность анализа бизнес-процессов для успешного существования в быстро меняющейся и конкурентной бизнес-среде. Основное внимание уделяется использованию Интернета вещей и моделированию информационных систем для повышения производительности организации.

Методологическая часть описывает исследовательский подход: сбор и анализ эмпирических данных в сравнении с научной литературой. В основе исследовательского подхода лежит интеграция данных Интернета вещей в реальном времени с моделированием информационных систем.

Результаты работы подтверждают первоначальное предположение, выявляя значительное влияние интеграции данных Интернета вещей и моделирования информационных систем на анализ бизнес-процессов. Это позволяет организациям достигать большей операционной эффективности, оптимизировать ресурсы и принимать обоснованные решения.

Подчеркивается практическая ценность гибридного подхода для организаций, желающих улучшить анализ своих бизнес-процессов. Интеграция Интернета вещей и моделирования информационных систем помогает оптимизировать процессы и повысить общую производительность.

Работа подтверждает важность и полезность использования гибридного подхода при анализе бизнес-процессов на основе Интернета вещей, подчеркивая преимущества интеграции данных Интернета вещей и моделирования информационных систем. Гибридный подход обладает потенциалом для улучшения бизнес-процессов и достижения успеха в современной конкурентной среде.

Ключевые слова: *моделирование гибридных информационных систем, анализ бизнес-процессов, Интернет вещей (IoT), Интеграция данных, операционная эффективность, Распределение ресурсов, аналитика в реальном времени, принятие решений, Эффективность организации, оптимизация процессов.*

Information about the authors

B. Askaruly* – master'S degree, Astana IT University; Republic of Kazakhstan, Astana; email: 222266@astanait.edu.kz

G.A. Abitova – PhD, Associate Professor; Astana IT University; Republic of Kazakhstan, Astana; email:Gulnara.Abitova@astanait.edu.kz. ORCID: https://orcid.org/0000-0003-3830-6905 .

Авторлар туралы ақпарат

Б. Аскарулы* – магистр дәрежесі, Astana IT University; Қазақстан Республикасы, Астана; email:222266@astanait.edu.kz

Г.А. Абитова – техника ғылымдарының кандидаты, доцент; Astana IT University; Қазақстан Республикасы, Астана; email:Gulnara.Abitova@astanait.edu.kz. ORCID: https://orcid.org/0000-0003-3830-6905 .

Сведения об авторах

Б. Аскарулы* – магистрант, Astana IT University; Республика Казахстан, Астана; email:222266@astanait.edu.kz

Г.А. Абитова – кандидат технических наук, доцент; Astana IT University; Республика Казахстан, Астана; email:Gulnara.Abitova@astanait.edu.kz. ORCID: https://orcid.org/0000-0003-3830-6905 .

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