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DEVELOPMENT OF A DECISION SUPPORT INFORMATION SYSTEM FOR MANAGING LARGE AGILE TEAMS IN IT PROJECTS

ФОРМУВАННЯ ІНФОРМАЦІЙНОЇ СИСТЕМИ ПІДТРИМКИ ПРИЙНЯТТЯ РІШЕНЬ ПРИ УПРАВЛІННІ ВЕЛИКОЮ AGILE КОМАНДОЮ В ІТ ПРОЄКТАХ

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Abstract. The purpose of this article was to develop a decision support information system for managing large Agile teams in IT projects, aimed at ensuring effective communication, coordination, responsibility distribution, and process adaptability.
The study utilized systems analysis methods to create a conceptual model and explore the relationships between Agile team members; mathematical modeling, comparison methods, and prototyping; machine learning techniques; and the Python programming language in the development of the information system.
The key findings of the study involve the integration of the Cynefin Framework as a tool for addressing challenges in managing large Agile teams. Among the most prominent challenges for project managers are the need for effective communication, process adaptability, distribution of responsibilities, and flexibility in decision-making. In response, a decision support information system has been proposed and developed to assist in managing large Agile teams in IT projects, which will help resolve these issues.
The scientific novelty of the research lies in the development and integration of the Cynefin Framework components into a conceptual model of an information system for effective management of large Agile teams in IT projects, ensuring adaptive decision-making in conditions of varying project complexity.
The practical significance of the study lies in the developed information system, which contributes to more effective decision-making in the management of teams in IT projects, including large Agile teams.
Key words: information system; IT project; large Agile teams; adaptability of processes; division of responsibility; innovative management; self-organization of teams; Cynefin Framework.

Анотація. Метою цієї статті було розробити інформаційну систему підтримки прийняття рішень для управління великими Agile командами в ІТ проєктах, яка б забезпечувала ефективну комунікацію, координацію, розподіл відповідальності та адаптивність процесів.
У дослідженні використовувались методи системного аналізу для створення концептуальної моделі, а також дослідження взаємозв’язків між члена Agile команди; математичне моделювання, методи порівняння та прототипування, методи машинного навчання, мова програмування Python при створенні інформаційної системи.
Основні результати дослідження полягають в інтеграції моделі Cynefin Framework як інструменту для вирішення проблем управління великою Agile командою, серед яких основне місце посідають такі виклики для менеджера проєкту, як потреба в ефективній комунікації, адаптивність процесів, розподіл відповідальності та гнучкість у прийнятті рішень. Відповідно запропонована та розроблена інформаційна систему підтримки прийняття рішень для управління великими Agile командами в ІТ проєктах, сприятиме вирішенню цих проблем.

Наукова новизна дослідження полягає в розробці та інтеграції компонентів моделі Cynefin Framework у концептуальну модель інформаційної системи для ефективного управління великими Agile-командами в IT-проєктах, що забезпечує адаптивне прийняття рішень в умовах різних типів складності проєктів.
Практична значимість дослідження полягає у розробленій інформаційній системі, яка сприяє більш ефективному прийняттю рішень в питаннях управлінню командами в IT проєктах, в тому числі великими Agile командами.
Ключові слова: інформаційна система; IT проєкт; великі Agile команди; адаптивність процесів; розподіл відповідальності; інноваційне управління; самоорганізація команд; Cynefin Framework.

FORMULATION OF THE PROBLEM

In today's world of fast-paced technology and unpredictable market conditions, organizations are constantly looking for ways to improve the effectiveness of their project teams. Agile methodology, with its principles of flexibility and adaptability, has become one of the key approaches in the field of project management, especially in the field of software development. However, managing a large Agile team is a significant challenge, as there is a need for effective decision-making mechanisms that would ensure coordinated team work and successful implementation of IT projects.

Among the main challenges faced by leaders of large Agile teams is ensuring effective communication and coordination between all team members, maintaining flexibility and adaptability of processes, sharing responsibility, and adapting to rapid changes in the IT project. These challenges present the scientific community with the task of developing and researching a decision support system model that contributes to the optimization of management processes in large Agile teams.

As part of this study, an in-depth analysis of the existing model, such as the Cynefin Framework, will be carried out, which provides the opportunity to solve each of the mentioned problems in particular, as well as the integration of certain components of this model to create an information system for decision support in the management of a large Agile team.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

The authors of the article [1] investigated the success factors of Agile teams in the field of software development, focusing on the personal characteristics of team members and the influence of psychological safety and team reflexivity on team effectiveness. Research findings [2] show that team performance factors, including Agile team relationships, team quality fit, team vision, team leader, and team performance requirements, had a significant impact on Agile team performance. The suitability test of the model proposed by the authors showed that 80% of productivity depends on Agile team effectiveness factors. The experience of analyzing the work of a remote team is presented in the study [3]. Described is the interpersonal communication network of this type of team, which becomes much more complex, especially when there is a significant time difference between project team members. This aspect is quite important to take into account in the modern conditions of popularization of the remote form of work on IT projects.

In the scholarly work [4], a study is described that examines the impact of Agile team «maturity» and cohesion on the efficiency of IT project implementation and the quality of its completion. The findings from study [5] show that high team stability and low staff turnover within IT projects are closely related to team iterations, which demonstrate a high rate of feature and increment creation for IT products.

Special attention should be given to the taxonomy of inter-team coordination mechanisms in large-scale Agile. The authors of study [6] proposed three key principles for this taxonomy.

SEPARATION OF PREVIOUSLY UNRESOLVED PARTS OF THE OVERALL PROBLEM

In a dynamic world of technological innovation and rapid market shifts, Agile methodology plays a crucial role in advancing IT project management, particularly in software development. However, managing a large Agile team presents leaders with a range of complex challenges, including the need for effective communication, process adaptability, clear responsibility distribution, and flexibility in decision-making. This study focuses on analyzing the Cynefin Framework model as a tool for addressing these challenges, offering strategies that include fostering open dialogue, adapting to rapid changes, promoting team self-organization, and responding to crisis situations. Developing and adapting such strategies can significantly enhance the efficiency of managing large Agile teams in IT projects, ensuring successful project delivery amid complex market.

PURPOSE OF THE RESEARCH

The purpose of this article was to develop a decision support information system for managing large Agile teams in IT projects, aimed at ensuring effective communication, coordination, responsibility distribution, and process adaptability.

METHODS, OBJECT AND SUBJECT OF RESEARCH

The study used methods of system analysis to create a conceptual model, as well as to study the relationships between members of the Agile team; mathematical modeling, comparison and prototyping methods, machine learning methods, Python programming language when creating an information system.

The object of the study is the process of developing an information system to support decision-making for the management of large Agile teams in IT projects.

The subject of the research is methods of developing an information system for decision support for managing large Agile teams in IT projects.

PRESENTATION OF THE MAIN MATERIAL

The Cynefin Framework model [7], developed by Dave Snowden, is a tool for understanding complexities and determining action strategies in various situations. It highlights the importance of thorough analysis and adaptability in today's fast-paced environment and is particularly valuable for Agile teams, enabling them to respond effectively to changes and challenges. Numerous challenges for large Agile team leaders [8] were examined, with the most significant ones selected for resolution through this model [9]. To enhance problem-solving, the development and validation of a scale for measuring team communication behaviors [10] were explored, aiming to improve the model's effectiveness.

To address the challenge of effective communication and coordination within large teams, the development of an intelligent analytics system has been proposed. This system would be integrated with Jira or Trello, utilizing data from these platforms alongside data from other communication channels, such as email, messaging apps, and video conferencing tools. The system will analyze communication among IT project team members, detecting response delays, interaction frequency, and task coordination effectiveness, providing recommendations for improvement.

The strategy consists of three main points:

1. Integration with the Jira or Trello API to collect data on tasks, sprints, comments, and task statuses. Simultaneously, integration with communication tools to analyze discussions and interactions.

2. Utilizing machine learning algorithms to analyze the collected data, identify interaction patterns, and determine potential problem areas in team communication and collaboration.

3. Based on the analysis, the system generates recommendations for improving communication and coordination processes, such as optimizing meeting schedules, revising task distribution, or introducing new communication tools.

A key feature of this approach is its adaptability and flexibility, which allows it not only to identify and address current communication and coordination issues within teams but also to anticipate potential challenges based on big data analysis. This approach could significantly contribute to improving the management of large Agile teams, distinguished by its deep integration with IT project management tools and the use of advanced machine learning and artificial intelligence technologies.

To address the challenge of maintaining flexibility and adaptability in processes, an adaptive management system called «Cynefin Navigator» can be developed. The core idea is to create a platform that utilizes the principles of Cynefin to analyze the current state of a project and determine which domain of Cynefin (Simple, Complicated, Complex, Chaotic) it falls within. Based on this analysis, the system provides recommendations for optimizing processes and management strategies.

The strategy of this implementation:

1. Utilizing machine learning algorithms to analyze IT project data (tasks, communication, outcomes) and classify its state into one of the Cynefin domains.

2. Developing a mechanism that allows the system to dynamically suggest changes in management and work processes according to the current Cynefin domain, as well as to anticipate future domain changes and prepare for them.

The uniqueness of this approach lies in the system's ability to not only react to current changes but also to anticipate future challenges, helping teams prepare for and adapt to new conditions. The use of the «Cynefin Navigator» could become a key tool for supporting the flexibility and adaptability of Agile teams, especially in environments where the pace of change and unpredictability are continually increasing. This solution will not only facilitate more effective management of IT projects but also provide teams with a tool for self-development and self-organization, enhancing their capacity for innovation and creative problem-solving.

To address the issue of responsibility distribution in large Agile teams for IT projects, it is important to develop an innovative solution based on the concept of «Dynamic Responsibility Allocation». This system utilizes data on team members skills, experience, and interests to create an optimal distribution of tasks and responsibilities that adjusts according to the needs of the IT project and the development of the team.

The main idea is to create an intelligent platform that analyzes team members' profiles, their work history, feedback, and self-assessments, as well as the current needs of the IT project. Utilizing artificial intelligence algorithms, the system generates recommendations for the most effective task distribution, maximizing the team's potential and fostering the skill development of its participants.

A strategy for achieving results:

1. Systematic collection of data on each team member, including their skills, experience, areas of interest, and history of completed tasks.

2. Identifying the key requirements and tasks of the current IT project, as well as forecasting future needs based on data regarding the project's progress.

3. Utilizing machine learning algorithms to analyze the collected data and create optimized scenarios for distributing tasks and responsibilities among team members.

This initiative for «Dynamic Responsibility Allocation» could significantly change the way teams approach task execution, transforming the challenge of responsibility distribution from a problem into an opportunity for growth and development. Implementing such a system will not only enhance the team's efficiency but also foster the personal development of its members, motivating them to improve their professional skills and engage in mutual support.

Forming a conceptual model. The conceptual model of the information system proposed in the study (Fig. 1) integrates both internal and external elements of IT project management [11]. This provides a deep understanding of the dynamics of large teams and enhances their ability to effectively respond to unpredictable changes.

The main components of the conceptual model are as follows:

Team [12]:

– business analyst;
– project manager;
– HR;
– developers: (UI/UX designer; DevOps; Backend developer; Frontend developer; QA).

Data:

– tools for organizing work in a team;
– communication channels: (e-mail address; work chat; video conferencing tools).

Resource:

– Jira/Trello;
– Cynefin Framework.
– Machine learning system for data analysis.

Key external agents, including clients, stakeholders [13, 14], and suppliers, function as the primary source of requirements and resources. Interaction with these agents is facilitated through feedback mechanisms, allowing management processes to be adapted according to the information received and ensuring a high level of customer satisfaction.

The team, as the central element of the system, consists of IT project managers, business analysts, HR managers, developers, UI/UX designers, DevOps, frontend and backend developers, as well as QA engineers. Each of these team members performs a defined role, interacting with one another through coordinated processes and unified communication and task management tools that ensure clear and effective collaboration.

The machine learning system is utilized to collect, analyze, and interpret data obtained from various sources, including project management tools and communication channels. This system provides key insights that contribute to objective decision-making and planning.

The adaptive control system «Cynefin Navigator» as an add-on synthesizes information from all model components and applies the Cynefin Framework to determine the optimal course of action. This system increases the flexibility and adaptability of Agile teams,

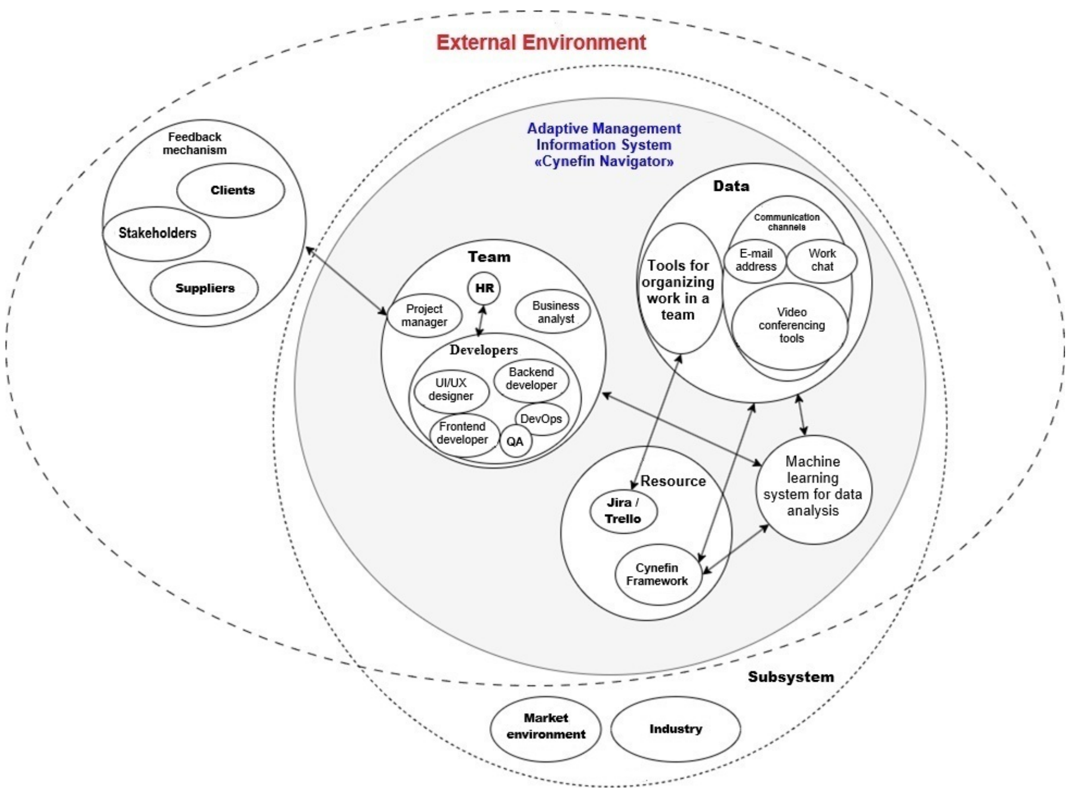


Fig. 1. Components of the Adaptive Management Information System «Cynefin Navigator»

allowing them not only to respond to current changes in IT projects, but also to anticipate future trends and challenges.

Formation of a mathematical model

1. Defining the purpose:

The main purpose is to minimize the discrepancy between the actual state of the IT project and the state defined by the system.

2. Definition of the objective function:

The objective function F is defined as the sum of losses across all IT projects:

$$F = \frac{1}{N}\sum_{i=1}^{N} L(y_i, \hat{y}_i) \rightarrow min$$

where L – loss function;
y_i – actual state of the IT project;
$\hat{y}$ – forecasted state;
N – number of states of the IT project.

3. Choice of the loss function:

The loss function is the cross-entropy loss [16], which is used for classification:

$$L(y_i, \hat{y}_i) = -y_i \log(\hat{y}_i) - (1 - y_i)\log(1 - \hat{y}_i)$$

4. Constraints:

Constraints on classification accuracy:

$$acc(\hat{y}, y) > \tau,$$

where τ – specified accuracy threshold.

Constraints on the analysis execution time:

$$T<T_{max},$$

where T – analysis execution time;
T_{max} – maximum allowable time.

5. Additional criteria:

– Flexibility of the system: the ability to adapt to new data without retraining the model from scratch.

– Scalability: the capability to handle increasingly larger volumes of data.

Definition of variables and parameters:

– y_i: Actual states of the projects according to Cynefin.

– $\hat{y}_i$: Predicted states of the projects according to Cynefin.

– N: Number of project states for analysis.

– τ: Accuracy threshold.

– T: Execution time for analysis.

– T_{max}: Maximum allowable analysis time.

The optimization problem is to find the parameters of the machine learning model that minimize the objective function F, satisfy the constraints on accuracy and execution time, and also optimize additional criteria such as flexibility and scalability.

The operation of the simplified system. The system begins by defining ranges of values for different states of the IT project. These states can range from «simple» to «very complex». Each state has its own range within which random values are generated, reflecting the level of complexity or orderliness of the tasks in the IT project. If the team can independently determine a more accurate readiness value for the IT project than the formal use of states according to the Cynefin Framework, normalized values can then be set.

Next, the system creates arrays with actual, predicted, and normalized values. These arrays represent different aspects of the IT project, such as how complex the tasks actually are, how well we have predicted them, and how we can normalize them for further analysis.

The next step is to calculate the inverse readiness of the IT project. The system compares the actual values with the values we predicted. If the actual value is greater than or equal to the predicted value, the IT project is considered complete. If not, the ratio of the actual value to the predicted value is computed, which helps determine how far behind we are from the plan.

After that, the system calculates the losses using binary cross-entropy, as shown in Figure 2. This is a complex method that allows for the assessment of the discrepancy between normalized values and the results of inverse readiness. The lower the loss value, the better we have managed the tasks.

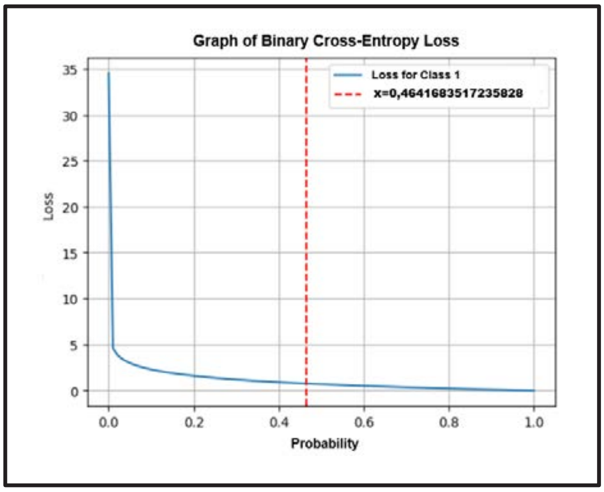


Fig. 2. Average Value of Binary Cross-Entropy Loss for Input Values of IT Project States

After calculating the losses, the system uses an exponential function to transform them. This provides a new metric that is easy to interpret. The lower the cross-entropy value, the better the state of the IT project.

Next, the system calculates the deviation from the average value of the transformed cross-entropy. This helps to analyze the state of the IT project in more detail and identify potential problem areas. Since the developed system is a «decision support and decision-making system», it will provide two alternatives based on the direct deviation from the desired state of the IT project and using the average value of the binary cross-entropy losses (see Fig. 3).

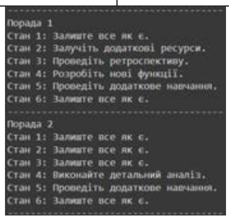
Input data	Simple, Complicated, Complex, Chaotic, Confused	
Predicted Advice 1, 2	Порада 1 Стан 1: Без змін Стан 2: Залучити додаткові ресурси Стан 3: Провести ретроспективу Стан 4: Розробити нову функцію Стан 5: Додаткове навчання Стан 6: Без змін	Порада 2 Стан 1: Без змін Стан 2: Без змін Стан 3: Без змін Стан 4: Детальний аналіз Стан 5: Додаткове навчання Стан 6: Без змін
The Result of the Cynefin Navigator's Operation	 Порада 1 Стан 1: Залиште все як є. Стан 2: Залучіть додаткові ресурси. Стан 3: Проведіть ретроспективу. Стан 4: Розробіть нові функції. Стан 5: Проведіть додаткове навчання. Стан 6: Залиште все як є. Порада 2 Стан 1: Залиште все як є. Стан 2: Залиште все як є. Стан 3: Залиште все як є. Стан 4: Виконайте детальний аналіз. Стан 5: Проведіть додаткове навчання. Стан 6: Залиште все як є.	

Fig. 3. Forecast data compared to the program's results (since the developed program has a Ukrainian-language interface, part of the figure is presented in Ukrainian)

DISCUSSION OF THE OBTAINED RESULTS

As part of the research, the task was to develop an intelligent decision support system for managing large Agile teams in IT projects. Therefore, the primary focus was on improving communication and coordination processes using the Cynefin Framework and machine learning algorithms. This system is intended to assist managers in identifying problem areas, analyzing them, and suggesting optimal solutions.

Possible predictive recommendations were proposed, and ultimately, it is evident that the expected outcomes align with the operation of the Cynefin Navigator program. This, in turn, indicates the effective use and implementation of the intended components of the program. Based on the results obtained, a third level of recommendations can be created, which will be based on a combination of the previous two. Furthermore, it will be enhanced by considering the weaknesses in team interactions within the IT project.

However, the research did not fully incorporate all the intended elements for the program, as this requires more in-depth studies, integration of third-party services, and a significant number of other factors.

In conclusion, it is worth noting that the developed information system compared actual values with predicted ones, identifying deviations from the plan. This enabled timely identification of problem areas and suggested necessary adjustments.

CONCLUSIONS

As a result of the conducted research, its goal was achieved, specifically to develop a decision support system for managing large Agile teams in IT projects that ensures effective communication, coordination, distribution of responsibilities, and process adaptability. Initially, the Cynefin Framework model was considered to address communication and coordination issues within large Agile teams. The next step involved developing a system that integrates with IT project management tools such as Jira or Trello for data collection and analysis. Machine learning algorithms were then utilized to analyze team interactions and identify problem areas. Ultimately, an information system was created that generates recommendations for improving communication processes and task coordination for managing large Agile teams in IT projects based on data analysis.

The Cynefin Framework model was successfully implemented at the initial stage in a reduced form, allowing for the analysis and classification of the IT project state. Integration with project management tools like Jira and Trello will be maintained to enhance the model.

The research demonstrated the high effectiveness of the proposed decision support system for managing large Agile teams in IT projects. The system provided adaptability and flexibility in processes, which are critical in fast-changing environments.

Future research may focus on additional aspects of process optimization and expanding the system's functionality for even greater effectiveness. It is recommended to implement similar systems in large Agile teams to improve IT project management and achieve high results in complex market conditions.

REFERENCES

[1] Eleftherakis, G., Dimitrova, V., Maglova, D., & Morogianni, V. (2024). Exploring Success Factors of Agile Teams: The Impact of Personality Traits, Psychological Safety, and Team Reflexivity on Performance. 2024 16th International Conference on Human System Interaction (HSI), Paris, France, 1-6, https://doi.org/10.1109/HSI61632.2024.10613563

[2] Mashmool, A., Khosravi, S., Joloudari, J.H., Inayat, I., Gandomani, T.J., & Mosavi, A. (2021). A Statistical Model to Assess the Team's Productivity in Agile Software Teams. 2021 IEEE 4th International Conference and Workshop Óbuda on Electrical and Power Engineering (CANDO-EPE), Budapest, Hungary, 11-18, https://doi.org/10.1109/CANDO-EPE54223.2021.9667902.

[3] Robinson, P.T. (2019). Communication Network in an Agile Distributed Software Development Team. 2019 ACM/IEEE 14th International Conference on Global Software Engineering (ICGSE), Montreal, QC, Canada, 100-104, https://doi.org/10.1109/ICGSE.2019.00015.

[4] Ramirez-Mora, S.L., & Oktaba, H. (2018). Team Maturity in Agile Software Development: The Impact on Productivity. 2018 IEEE International Conference on Software Maintenance and Evolution (ICSME), Madrid, Spain, 732-736, https://doi.org/10.1109/ICSME.2018.00091.

[5] Scott, E., Charkie, K.N., & Pfahl, D. (2020). Productivity, Turnover, and Team Stability of Agile Teams in Open-Source Software Projects. 2020 46th Euromicro Conference on Software Engineering and Advanced Applications (SEAA), Portoroz, Slovenia, 124-131, https://doi.org/10.1109/SEAA51224.2020.00029.

[6] Berntzen, M., Hoda, R., Moe, N.B., & Stray, V. (2023). A Taxonomy of Inter-Team Coordination Mechanisms in Large-Scale Agile. 2023 IEEE Transactions on Software Engineering, 49, 2, 699-718. https://doi.org/10.1109/TSE.2022.3160873

[7] Cynefin framework / Model' «Kenevin». (2022). Retrieved from https://www.maxzosim.com/cynefin-framework-model-kenevin/

[8] Shho take Agile i jak jogo zastosuvaty v biznesi. (2024). Retrieved from https://brainrain.com.ua/uk/chto-takoe-agile-ua/

[9] 8 Agile Project Management Challenges: A Comprehensive Guide. (2024). Retrieved from https://www.theknowledgeacademy.com/blog/agile-project-management-challenges/

[10] Development and validation of a scale to measure team communication behaviors. (2022). Retrieved from https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2022.961732/full

[11] Basic Project Management Principles for Beginners. (2023). Retrieved from https://worksection.com/en/blog/basic-project-management-principles-for-absolute-beginners.html

[12] Ziuziun, V. (2023). Importance of personnel selection in personnel management of an IT organization. 2nd International Scientific and Practical Internet Conference «Global Society in Formation of New Security System and World Order», 41-42. URL: http://www.wayscience.com/konferentsiya-2-27-28-lipnya-2023/

[13] Hto taki stejkholdery ta jak z nymy pracjuvaty? (2024). Retrieved from https://online.novaposhta.education/blog/hto-taki-stejkholderi-ta-yak-z-nimi-pracyuvati

[14] Kubiavka, L., Zaremba, V., & Ziuziun, V. (2024). Application of Game Theory Methods to Optimize the Stakeholder Management Process. 2024 IEEE 4th International Conference on Smart Information Systems and Technologies (SIST), Astana, Kazakhstan, 647-651, https://doi.org/10.1109/SIST61555.2024.10629255

[15] Ziuziun, V., & Kolomiiets, A. (2023). Aspects of decision-making in the management of human resources in it projects of organizations. Mizhnarodna naukovo-praktychna konferencija «Intelektual'ni informacijni systemy v Upravlinni projektamy ta programamy», Kharkiv 45-49. https://doi.org/10.30837/iisrrm.2023.09

[16] Entropy and crossentropy (2024). Retrieved from https://dementiy.github.io/notes/cross-entropy/

СПИСОК ВИКОРИСТАНОЇ ЛІТЕРАТУРИ

[1] Eleftherakis, G., Dimitrova, V., Maglova, D., & Morogianni, V. (2024). Exploring Success Factors of Agile Teams: The Impact of Personality Traits, Psychological Safety, and Team Reflexivity on Performance. 2024 16th International Conference on Human System Interaction (HSI), Paris, France, 1-6, https://doi.org/10.1109/HSI61632.2024.10613563

[2] Mashmool, A., Khosravi, S., Joloudari, J.H., Inayat, I., Gandomani, T.J., & Mosavi, A. (2021). A Statistical Model to Assess the Team's Productivity in Agile Software Teams. 2021 IEEE 4th International Conference and Workshop Óbuda on Electrical and Power Engineering (CANDO-EPE), Budapest, Hungary, 11-18, https://doi.org/10.1109/CANDO-EPE54223.2021.9667902.

[3] Robinson, P.T. (2019). Communication Network in an Agile Distributed Software Development Team. 2019 ACM/IEEE 14th International Conference on Global Software Engineering (ICGSE), Montreal, QC, Canada, 100-104, https://doi.org/10.1109/ICGSE.2019.00015.

[4] Ramirez-Mora, S.L., & Oktaba, H. (2018). Team Maturity in Agile Software Development: The Impact on Productivity. 2018 IEEE International Conference on Software Maintenance and Evolution (ICSME), Madrid, Spain, 732-736, https://doi.org/10.1109/ICSME.2018.00091.

[5] Scott, E., Charkie, K.N., & Pfahl, D. (2020). Productivity, Turnover, and Team Stability of Agile Teams in Open-Source Software Projects. 2020 46th Euromicro Conference on Software Engineering and Advanced Applications (SEAA), Portoroz, Slovenia, 124-131, https://doi.org/10.1109/SEAA51224.2020.00029.

[6] Berntzen, M., Hoda, R., Moe, N.B., & Stray, V. (2023). A Taxonomy of Inter-Team Coordination Mechanisms in Large-Scale Agile. 2023 IEEE Transactions on Software Engineering, 49, 2, 699-718. https://doi.org/10.1109/TSE.2022.3160873

[7] Cynefin framework / Модель «Кеневін». (2022). URL: https://www.maxzosim.com/cynefin-framework-model-kenevin/

[8] Що таке Agile і як його застосувати в бізнесі. (2024). URL: https://brainrain.com.ua/uk/chto-takoe-agile-ua/

[9] 8 Agile Project Management Challenges: A Comprehensive Guide. (2024). URL: https://www.theknowledgeacademy.com/blog/agile-project-management-challenges/

[10] Development and validation of a scale to measure team communication behaviors. (2022). URL: https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2022.961732/full

[11] Basic Project Management Principles for Beginners. (2023). URL: https://worksection.com/en/blog/basic-project-management-principles-for-absolute-beginners.html

[12] Ziuziun, V. (2023). Importance of personnel selection in personnel management of an IT organization. 2nd International Scientific and Practical Internet Conference «Global Society in Formation of New Security System and World Order», 41-42. URL: http://www.wayscience.com/konferentsiya-2-27-28-lipnya-2023/

[13] Хто такі стейкхолдери та як з ними працювати? (2024). URL: https://online.novaposhta.education/blog/hto-taki-stejkholderi-ta-yak-z-nimi-pracyuvati

[14] Kubiavka, L., Zaremba, V., & Ziuziun, V. (2024). Application of Game Theory Methods to Optimize the Stakeholder Management Process. 2024 IEEE 4th International Conference on Smart Information Systems and Technologies (SIST), Astana, Kazakhstan, 647-651, https://doi.org/10.1109/SIST61555.2024.10629255

[15] Ziuziun, V., & Kolomiiets, A. (2023). Aspects of decision-making in the management of human resources in it projects of organizations. Міжнародна науково-практична конференція «Інтелектуальні інформаційні системи в Управлінні проєктами та програмами», Харків, ХНУРЕ, 45-49. https://doi.org/10.30837/iisrrm.2023.09

[16] Entropy and crossentropy (2023). URL: https://dementiy.github.io/notes/cross-entropy/

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