# Decision Support for Requirements Prioritization in Software Engineering

Oleksandr Nesterenko[2], Oleksandr Trofymchuk[1]

[1] *Institute of Telecommunications and Global Information Space, Chokolivskiy bulv., 13, Kyiv 03186, Ukraine*
[2] *International European University, Glushkov av., 42, Kyiv 03127, Ukraine*

**Abstract**

In software development processes, requirements prioritization plays a key role. gathering of requirements and their objective prioritization can ensure a sequential and effective development of a software project. With the increasing complexity of software, which is a characteristic of today, problems related to defining requirements also increase. It becomes increasingly challenging to identify the most important and essential requirements in a stream of wishes and recommendations, determining what should be the starting point of development and where the most attention should be focused. The task of requirements prioritization is multi-criterial and poses significant cognitive loads. Most researchers and professionals suggest expert methods for decision-making in such environments, which to some extent help solve the tasks at hand. How-ever, among the known requirements prioritization methods, practically all involve qualitative descriptive analysis based on brainstorming techniques. At the same time, in the modern conditions of digitalization, providing decision support based on a comprehensive presentation of the information model of the subject area and processing through information technologies for quantitative assessment of alternatives is more promising. Another important capability of modern technologies is visualization of decision-making processes. Thus, this work explores a comprehensive prioritization method that involves a full presentation of the information picture of the subject area, including in the form of computer ontologies, applying a quantitative AHP method for comparing requirements, and visualized data in graphs for considering alternatives. Additional use of a modified SWOT matrix allows for the disaggregation of requirements into their individual characteristics and consideration of their advantages for problem evaluation. The existence of such tools and the capabilities of information technologies confirm the effectiveness and stability of the proposed method.

**Keywords**

Requirements engineering, computer ontologies, visualization, graphs, AHP, SWOT

## 1. Introduction

> Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it.
>
> Samuel Johnson (Dr Johnson), 1775

Software requirements engineering is a common and essential discipline in IT companies. The field of Software Requirements, according to international recommendations in software engineering, stands as the cornerstone of knowledge consolidation. However, it is not solely this that defines its uniqueness and importance in the software lifecycle. Indeed, the success of a software project and ultimately the quality of the resulting product significantly depend on the adequate definition of functions, conditions, and performance constraints.

*14th International Scientific and Practical Conference from Programming UkrPROGP'2024, May 14-15, 2024, Kyiv, Ukraine*
* Corresponding author.
oleksandr_nesterenko@ieu.edu.ua (O. Nesterenko), trofymchuk@nas.gov.ua (O. Trofymchuk)
0000-0001-5329-889X (O. Nesterenko), 0000-0003-3358-6274 (O. Trofymchuk)

Gathering requirements is a non-trivial task and is typically carried out through multiple iterations of communication between the developer and the client. However, an even more challenging task is identifying the most important and essential aspects amidst a stream of desires and recommendations, determining what needs to be prioritized and where the greatest attention should be focused. The requirements analysis stage is the most crucial, as its flaws could necessitate further redesign of individual components or the entire system as a whole. Therefore, prioritization, or ranking of requirements, can facilitate their structuring, create conditions for their classification and systematization, helping the development team understand their significance and value, and make effective decisions regarding resource allocation and project management.

The decision-making task regarding the prioritization of requirements is multi-criteria and involves significant cognitive loads. Researchers and experts propose a variety of approaches to support decision-making in such environments. Most of them rely on expert methods, which to some extent enable the resolution of the stated tasks. However, among the known methods (MoSCoW, Kano, Story Mapping, KJ, Feature Buckets), practically all entail qualitative descriptive analysis relying on brainstorming techniques. Meanwhile, in the current conditions of digitization, providing decision support in analytical activities, especially in multi-criteria cases, based on comprehensive presentation of the informational landscape of the subject area and processing quantitative assessments of alternatives through information technologies, appears more promising.

Thus, there exists a pressing issue of defining a quantitative method and corresponding information technology toolkit to address the important practical task of supporting expert decision-making in requirements analysis processes, particularly for their prioritization.

## 2. Analysis of recent research and publications

The significant role of requirement prioritization in software development is demonstrated by a considerable number of publications, particularly those dedicated to systematic analysis of important factors in determining requirement priorities, such as risks, cost, time, etc. [1, 2]. These works highlight the use of several dozen different requirement prioritization methods. At the same time, it is noted that these prioritization methods have certain limitations and drawbacks. There are also issues with selecting prioritization criteria, which are often determined intuitively rather than through comprehensive analysis of their importance. Moreover, the importance of criteria may vary depending on how deeply the requirement is elaborated during the development process [3].

The existence of a large number of different methods (techniques) for prioritizing requirements is associated not only with the fact that using the same technique for ranking requirements at different stages may lead to limited advantages but also primarily with the diversity of specific features of software tools and systems. Therefore, researchers strive to propose approaches for hybridizing existing methods to achieve greater universality and efficiency. In the work [4], the MCBRank method is proposed, which incorporates the well-known MoSCoW method and Case-Based Ranking method based on statistical analysis of cases to improve the accuracy of priority determination. In the work [5], a hybrid model is discussed, which includes a known prioritization technique and the use of critical factors of software project based on their quantified scores.

In one of the well-known requirements development methods, AGORA (Attributed Goal-Oriented Requirements Analysis), decision-makers use subjective assessments to determine requirement priorities. In the work [6], to ensure the computation of objective values, this method is proposed to be extended using the Analytic Hierarchy Process (AHP) method. In the work [7], attention is drawn to the fact that conventional requirement prioritization methods, especially considering the attributes of software quality, are qualitative in nature. Therefore, this article also proposes the AHP technique for quantitative ranking of requirements, design decisions, and tactics, simultaneously taking into account the relationships between system quality requirements and design tactics and principles.

At the same time, it's important to note that in complex cases, such as strategic analysis, there's a need to consider a significant array of internal and external factors when prioritizing, assessing requirements against generalized criteria such as prospective benefits, existing opportunities, potential costs, acceptable risks, etc. One of the tools most commonly used for such examination is SWOT analysis.

Usually, SWOT analysis is applied at the macro level of strategic analysis. Despite its advantages and popularity, this method has faced criticism, particularly regarding the lack of a methodology for quantitatively assessing the results of compiling a SWOT matrix. The convenience of using the primary SWOT is enhanced by the hybrid SWOT/AHP method, introduced as early as the early 2000s [8]. Since then, this approach has gained widespread popularity and is applied in many fields [9, 10].

Many researchers share the view that decision support in analytical activities, especially in multi-criteria cases like requirement analysis, is directly related to providing a comprehensive representation of the informational landscape of the subject area (SA). Therefore, in modern conditions, supporting the cognitive process of requirement prioritization primarily involves supporting domain engineering based on relevant models and knowledge [11]. In this regard, as a methodological basis for solving the problem of rational decision-making by experts, it is necessary, first of all, to establish the optimal composition of information required for effective decision-making, and to ensure the collection, presentation, and analysis at various levels of a significant amount of heterogeneous data [12]. Therefore, an important element of modern decision support systems is a knowledge base that represents the informational model of SA. Among the existing approaches to such models, representing SA in the form of computer ontologies is considered the most adequate recently [13]. Increasing the effectiveness of this approach involves the application of mechanisms for the shared use of SA ontologies and ontologies related to software engineering processes [14, 15].

Many studies, particularly in the field of social sciences, confirm the observation that an important capability of modern technologies is providing visualization of decision-making processes. Widely used tools to enhance understanding of problems and ultimately improve decision-making include the application of graphical means for information visualization. Research shows that data visualized in graphs require less cognitive effort for interpretation compared to textual (tabular) data [16, 17].

Thus, unresolved aspects of the overarching problem of making effective decisions regarding the prioritization of software requirements are associated with information support, quantitative computation, and visualization of the prioritization process, which this article addresses.

Based on this, the objectives of the article are to explore a comprehensive method for decision support regarding requirement prioritization, taking into account information provision, quantitative assessment of requirements, and visualization of the comparison process among requirements.

## 3. The theoretical research backgrounds

The prioritization methods that have proven themselves worldwide and are used in the managerial environment for ranking requirements of software projects mainly operate with qualitative categories. Table 1 provides a list of some such methods and the set of categories they employ.

**Table 1**
Categories of well-known requirements prioritization methods

| Method | Categories |
|---|---|
| MoSCoW | the most important requirements; important requirements; desired requirements; non-critical requirements |
| Kano | expected properties; basic properties; admirable properties |
| Story Mapping | criticality |
| KJ | the most important groups of requirements; the most important requirements in the group of most important requirements |
| Feature Buckets | requirements that can greatly affect the target indicators of the product; additional improvements; requirements important for the pleasant surprise of the customer; strategic requirements important for the future |
| Impact-effort matrix | influence; effort |

From the data in Table 1, it is easy to notice that these methodologies are based on fairly similar techniques of enhancing the intellectual efforts of participants in group brainstorming sessions, but they operate with categories that lack clear definitions. What exactly are the "most important" requirements? Or the "non-critical" requirements? Considering that in these methods, the preference model used by experts is undefined and vague, and preferences differ among different experts, this leads to the allocation of scores for the same object. As a result, the level of inconsistency in comparisons is often decisive in the analysis results.

It is commonly believed that experts are experienced, professional, and honest. However, in practice, there are cases where experts attempt to manipulate results in their favor, or they hesitate and make mistakes due to psychological state, distractions, or limitations in knowledge and information. This necessitates the implementation of additional mechanisms to identify manipulators and those who make mistakes, and to minimize their influence on group consensus. Thus, further potential project problems essentially stem from what seemed like a simple stage - experts determining certain weights (priorities) of alternatives when forming a ranked list of requirements. It is unrealistic to expect humans to change for the better in this regard in the near future. Therefore, quantitative methods were proposed, which in a certain way create conditions for reducing the subjectivity of experts.

One of the prioritization methods based on quantitative data is RICE, an abbreviation derived from four factors used to assess and prioritize items: Reach, Impact, Confidence, and Effort. To obtain a RICE score, these factors, presented in a quantitative dimension, need to be combined using a defined formula. Expert quantitative comparisons for ranking alternatives have also found application in the well-known Analytic Hierarchy Process (AHP), proposed by the American mathematician T. Saaty in the late 1970s. The method involves hierarchically decomposing the problem into simpler components and step-by-step establishing priorities for the evaluated components using pairwise comparisons.

However, today, information technologies that provide quantitative decision support methods can already improve the situation. Many researchers share the view that decision support in analytical activities, especially in multi-criteria cases, is directly linked to comprehensive presentation of the informational landscape of the subject area. In this regard, as a methodological basis for addressing the problem of rational decision-making by experts regarding the selection of requirements, it is necessary first and foremost to establish the optimal composition of information required for requirement assessment, ensuring collection, presentation, and analysis at various levels of significant heterogeneous data sets.

Thus, in contemporary decision-making processes, there is a growing shift from relying solely on individual judgments to increasing the importance of having access to a greater amount of necessary information (Figure 1).

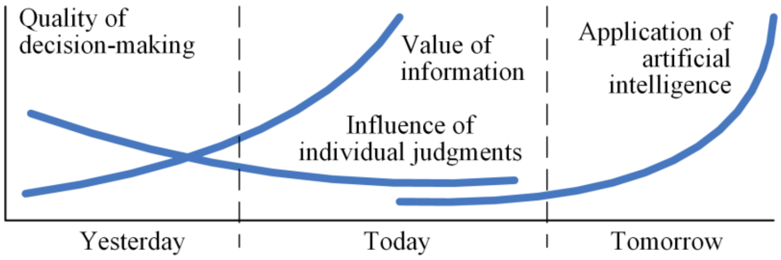


**Figure 1:** The transition from the influence of individual judgments on decision-making to the importance of the use of information technologies/

The availability of the necessary structured data opens up wide opportunities for requirements prioritizing of various modern methods, such as the use of graphs for visualization, machine learning for processing large-scale projects, decision-making based on many criteria, optimization methods using evolutionary algorithms, etc. [18]. In the modern conditions of activity in software engineering, an ever-increasing unstructured text and multimedia content is inherent, the processing of which is associated with tangible problems. Overcoming these problems can be seen on the basis of information modeling of the subject environment and the implementation of progressive information technologies, including artificial intelligence technologies [19].

Among the existing approaches to information models of SA, the representation in the form of computer ontologies has recently been considered the most adequate [13, 14]. In general, such an ontology comprises informational descriptions based on an object-oriented procedure for formalizing concepts and their binary relationships. Considering that expertise in the characteristics of alternatives is crucial for making objective decisions, the simultaneous application of elements of ontological descriptions enhances the specificity of the model and provides a clearer understanding of the significance of each requirement for project success.

On the other hand, to facilitate expert activity, structured formats for describing alternatives are necessary. This poses a significant challenge because the readability and comprehensibility of documented information largely determine the success and effectiveness of experts' contributions to the requirements prioritization process. In this sense, a crucial capability of modern technologies is providing visualization of decision-making processes. Graphical tools are widely used to enhance understanding of problems and, ultimately, improve decision-making. Creating graphical models to determine the impacts of various factors demonstrates the convenience of their application. For instance, in the case of using AHP, such visualization provides experts with an effective tool to prevent transitive inconsistency, which, as known, is not controlled in this method [12].

So, the cognitive decision-making process for the problem of requirements prioritization with information technology support can be presented in Figure 2 [20].

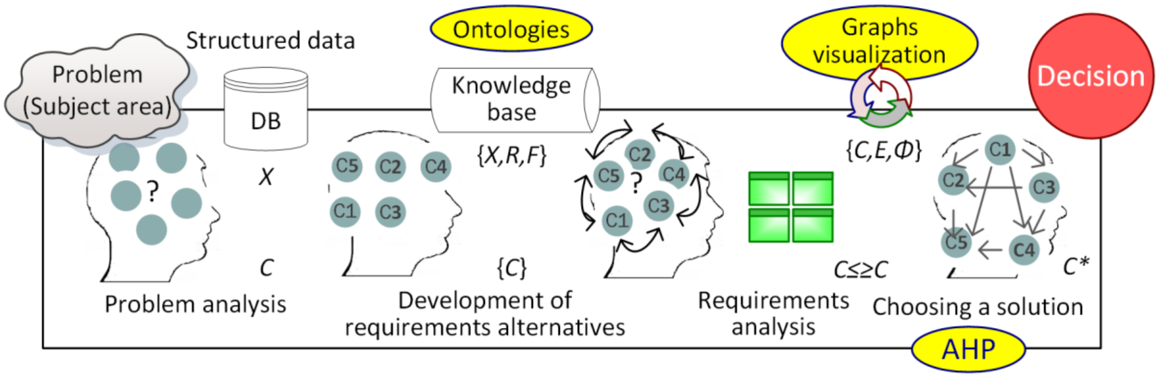


**Figure 2:** The cognitive decision-making process for the problem of requirements prioritization with information technology support.

The process begins with organizing data about the concepts X of the software project SA of the related to the requirements. Information is sought and existing databases are utilized. Simultaneously (in case of absence), the formation (or modification, if present) of an ontological base takes place, which defines the relationships R between the concepts X and the functions F of their interpretation. This allows for the determination of the set of requirements {C} and a clear understanding of their characteristics. Based on this knowledge, a requirements analysis is conducted, the results of which can be quantified. For this, it is advisable to apply RICE, SWOT and other similar methodologies. To make a decision, a comparison of alternatives needs to be conducted to determine the ranked list. For this purpose, it is advisable to use AHP. To ensure the convenience and clarity for experts when comparing alternatives, the AHP process is modified by applying graph visualization tools. Vertices C of the graph are connected by directed arcs E, which are loaded with quantitative evaluations Φ of the preferences of alternatives formed by the experts.

Such organization of the well-known decision-making process, through the use of information technologies, allows for the creation of a universal approach to decision-making regarding the requirements prioritization.

## 4. Research findings

### 4.1. An approach to requirements analysis based on the SWOT methodology

The proposed approach for supporting decisions regarding of requirements prioritization is shown in Figure 2, can be applicable for various prioritization tasks. A special stage in the given scheme is the requirements analysis. Its importance increases in cases of complex tasks and large projects, when there is a need to take into account a significant set of internal and external factors in the analysis of requirements and their subsequent ranking. Usually there is a need to evaluate requirements according to such criteria as prospects of benefits, existing opportunities, possible costs, acceptable risks, etc. Many methods have been developed for such consideration, but one of the most frequently used is SWOT analysis.

Typically, SWOT analysis is applied at the macro level of strategic analysis, but the method's versatility allows it to be used in other types of problem examination as well. In this study, we propose the reverse application of the SWOT methodology, i.e., at the micro-level, specifically for analyzing the characteristics of requirements.

A distinctive feature of SWOT is that it combines internal (Strengths, Weaknesses) and external factors (Opportunities, Threats) that affect the object of study. It considers both positive influences (Strengths, Opportunities) and negative influences (Weaknesses, Threats). We will utilize the features of SWOT and the ideas from the well-known requirements prioritization methods discussed earlier to create a specialized analysis matrix (Table 2). From the perspective of software engineering, a strong point for the requirement under consideration should be its impact on the quality of the future software product. Meanwhile, a weak point would be the labor costs required to implement this requirement.

**Table 2**

Comparison of SWOT and QECR factors

| SWOT | QECR |
|---|---|
| Strengths | Quality |
| Weaknesses | Effort |
| Opportunities | Consumers |
| Threats | Risks |

Accordingly, the opportunities for project development arising from the implementation of a requirement are directly linked to market and consumer needs. Finally, it is essential to assess the risks to the project associated with the priority implementation of the requirement and take measures to mitigate or manage these risks.

Thus, the QECR-analysis matrix of requirements will look as shown in Table 3.

**Table 3**

Features of requirements QECR-analysis

| Requirement properties | Requirement advantages | Requirements disadvantages |
|---|---|---|
| Internal | (Q) Quality | (E) Effort |
| External | (C) Consumers | (R) Risks |

Thus, constructing the QECR matrix allows experts to consider important factors related to requirements that might be underestimated in traditional requirements analysis. The proposed approach involves creating a QECR matrix for each requirement, with its factors considered in the matrix's quartiles depending on the requirement's impact on the project.

It should be noted that despite its advantages and popularity, the SWOT analysis method has faced criticism, particularly for its lack of a methodology for the quantitative evaluation of SWOT matrix results. Many researchers suggest improving the primary SWOT by applying the hybrid SWOT/AHP method. Based on this, it is also considered appropriate to complement the construction of the QECR matrix by applying AHP.

Given the above, the decision support approach based on QECR/AHP is implemented using an algorithm that consists of two main stages (Fig. 3). At the first, an information model based on ontologies is formed and preselection of requirements is carried out. On the second, an experiment is actually being conducted.

At the first stage, during the analysis of the subject area and the gathering of requirements, an information model is formed based on ontologies (ontology of the subject area, task ontologies). Next, a preselection takes place, where a list of requirements for ranking is formed and the characteristics of these requirements are analyzed.

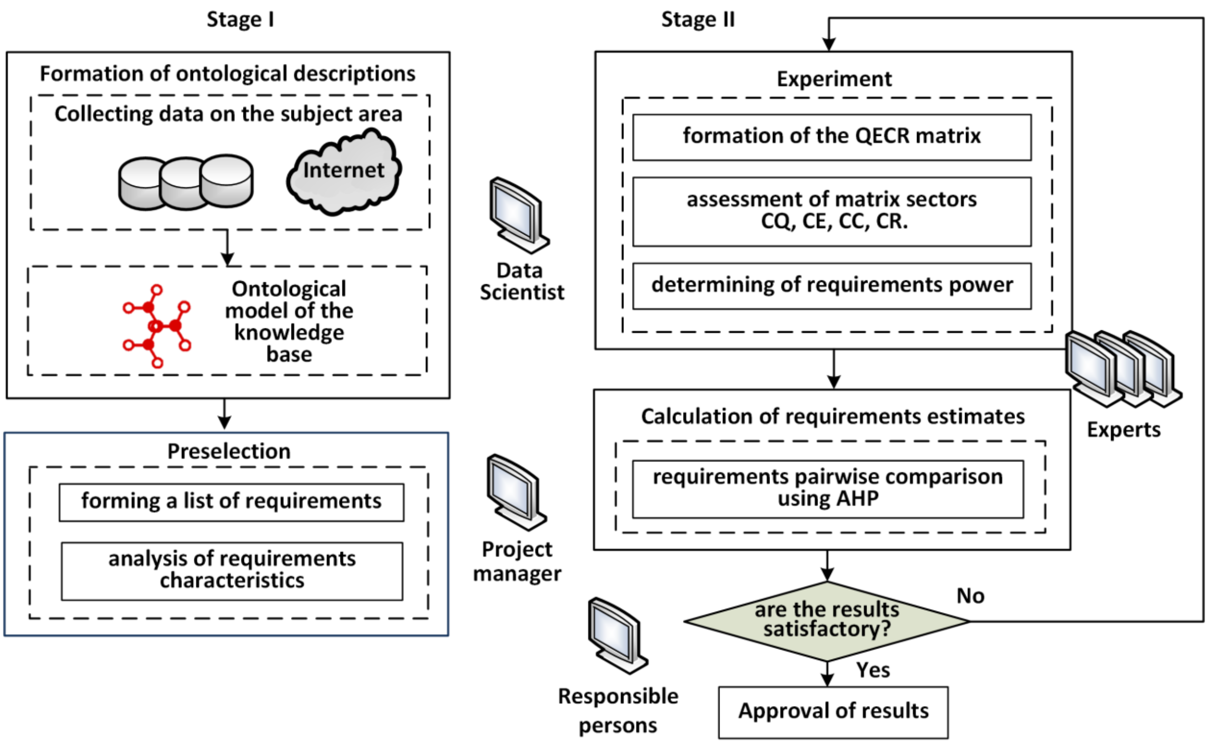


**Figure 3:** Algorithm of the proposed method applications.

The experimental stage begins with the formation of the QECR matrix for the requirements from the list. Each element of the QECR matrix sectors is considered based on specific parameters of the requirement, which are available from the formed information sources (project databases and knowledge bases), and is evaluated in a quantitative (point-based) measure.

When determining the expert evaluations of requirements $A_r$, their quantitative and qualitative indicators are summarized in a quantitative (point-based) measure according to a certain conventional scale. For example: negligible impact on the project – 1 point, low – 3 points, medium – 5 points, high – 7 points, very high – 9 points. Thus, we determine the evaluations of the components for each requirement, namely $A_Q$, $A_E$, $A_C$, and $A_R$. Next, the power of each requirement $P_r$ is determined for the four sectors of the QECR:

$$P_r = \frac{A_Q + A_C}{A_E + A_R}. \quad (1)$$

From the received data, it is already possible to determine the order of requirements ranking. However, this is only the first assessment that orients the expert in the situation. Next, it is advisable to conduct a pairwise comparison of the alternatives, during which the expert can apply additional judgments, especially if some alternatives have close QECR estimation. Additionally, to enhance the level of objectivity, it is essential to consider the evaluations of the involved experts. Each expert will have their own opinion and thus their own results for the QECR. In this case, it is advisable to apply AHP to conduct comparisons based on the obtained estimates Pr and consolidate the results of experts by convolution.

## 4.2. An example of requirements analysis

Let's consider a simplified example of the application of the proposed approach to support a decision to requirements prioritize. Let's imagine that the first stage of the above algorithm has been carried out for some software project. It should be noted that the creation of a project database is an essential management procedure. Data regarding requirements and their attributes are crucial elements of this database. Today, the focus is increasingly on the intellectualization of data analysis, which necessitates the formation of a knowledge base based on relevant models, specifically, as proposed, ontological ones. Due to the complexity and specificity of each detailed project, which requires additional explanations, the description of the implementation of such a model requires a separate article and is not given here. However, it is worth demonstrating the complexity of relations between classes and concepts of such a model using the example of the meta-ontology of project requirements in the form shown in Figure 4 taxonomies.

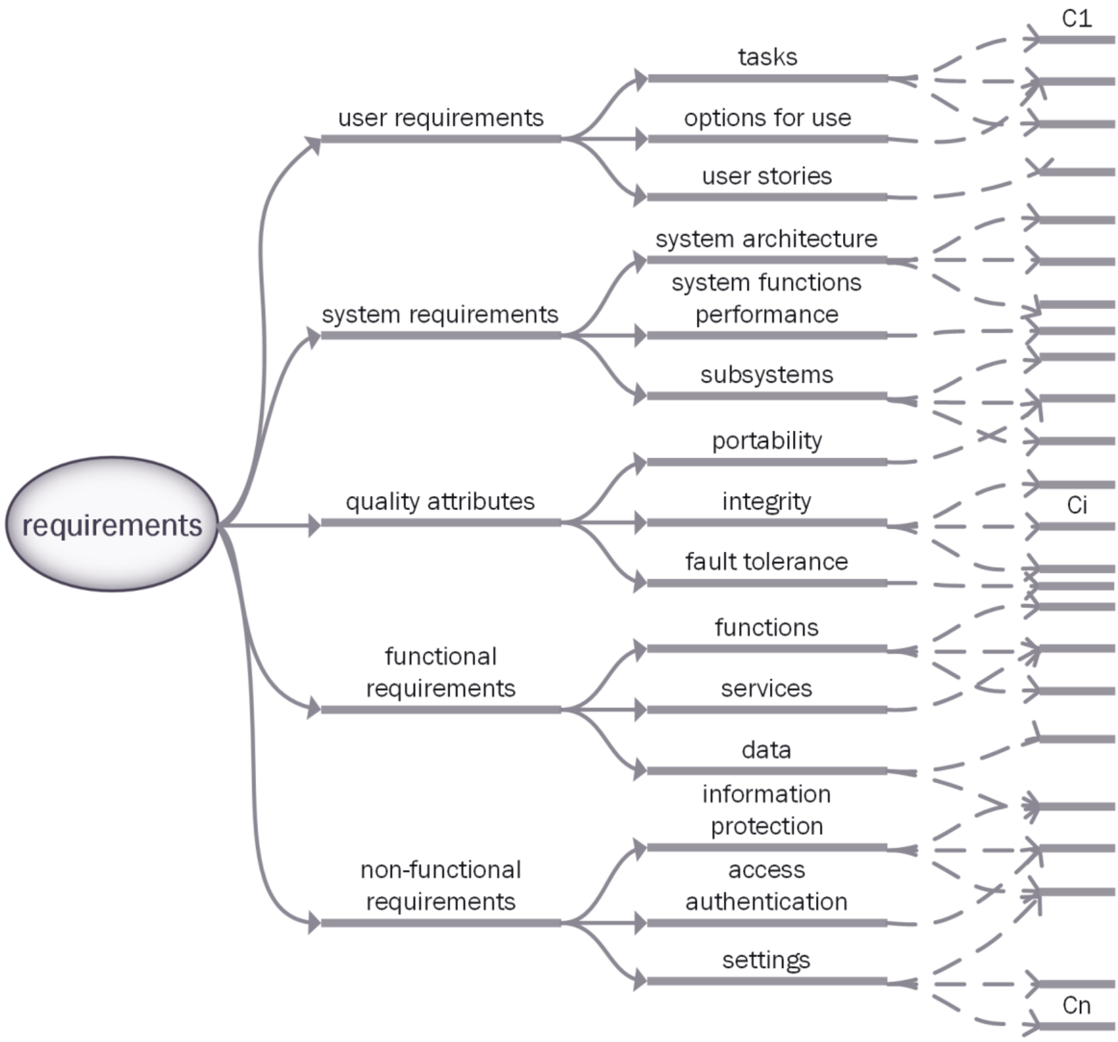


**Figure 4:** A meta-ontology example of project requirements

Moving to the second stage, as input data, we receive a stacked list of five requirements for analysis, selected from a set {C}. This choice was made by a formed group of experts who conducted a preliminary analysis of requirements using information sources and an ontological model. Next, the selected requirements are assessed by experts according to the QECR methodology and the mentioned rating scale. In Table 4 shows the results of such an assessment by one expert. The power of requirements is obtained using formula (1).

From the data in this table, the ranking order of requirements is already visible. However, as indicated above, it is further expedient to conduct a pairwise comparison of alternatives with the use of AHP for reasonable consideration and consolidation of the assessments of experts from the group.

**Table 4**
An example of an expert assessment of requirements characteristics according to the QECR methodology

| Requirements | AQ | AE | AC | AR | The power of requirements Pr |
|---|---|---|---|---|---|
| C1 | 9 | 1 | 3 | 1 | 6.00 |
| C2 | 7 | 1 | 5 | 3 | 3.00 |
| C3 | 9 | 1 | 3 | 5 | 2.00 |
| C4 | 1 | 9 | 3 | 3 | 0.33 |
| C5 | 5 | 3 | 7 | 6 | 1.50 |

The preparation of data for AHP and the algorithm for using this method are well known and therefore not detailed here. However, as previously mentioned, it is proposed to enhance the pairwise comparison process in AHP by incorporating the visualization of the preference determination process for alternatives. Figure 5 shows an example of visualization on graphs of the process of further ranking of requirements using AHP (the arcs of the graph are loaded with the Saati scale preference scores used in AHP).

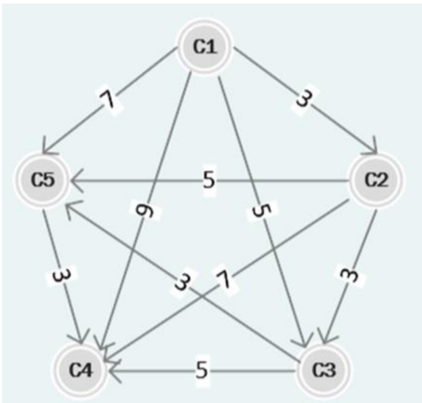


**Figure 5:** An example of visualization on graphs of the process of ranking requirements in AHP.

The advantage of the proposed approach is that, thanks to automation, it is possible to relatively quickly conduct iterative experiments on requirements ranking of until an agreed result is reached. This is useful for comparing the results obtained by different groups of experts, or in the case of adjusting the information model of the subject area, or in other cases.

## 5. Conclusions and prospects for further research

The global industrial demand for high-quality software in the context of digital transformation is continuously growing. On the other hand, the analysis conducted indicates existing gaps between the industry, technological trends, and decision support in the field of software engineering. Specifically, this pertains to requirements engineering, where many modern technologies are relatively underutilized. It is believed that the main reasons for this crisis lie in the slow adaptation of management systems to current market needs, the lack of time and resources, and the difficulties in acquiring the necessary practical skills. However, in our times, enhancing the level of technological support for decision-making should be a key focus in software engineering.

In modern conditions, particularly in software engineering, there is a constantly increasing amount of unstructured textual and multimedia content. In practice, processing this content is associated with significant challenges. This controversy hinders the innovative development of the software engineering field, negatively affecting the pace of its modernization. To some extent, it is proposed to fill the aforementioned gaps based on information modeling of the subject environment and the implementation of relevant advanced information technologies for decision support.

The systematic management of requirements can form the basis of informational resources developed in project support systems. These resources can be utilized not only by responsible personnel within enterprises for the formation and development of business activities but also directly by specialists during the project task development process. In this regard, the article proposes a solution to the pressing issue of informational support and the establishment of a quantitative method for supporting expert activities in the requirement analysis processes, particularly for their prioritization.

The method is based on the comprehensive use of an ontological model of the subject area, the SWOT methodology for requirement analysis, and AHP with graph-based visualization of the pairwise comparison processes. This approach has been implemented in the corresponding informational and technological toolkit. The prospect of further research involves enhancing the methods of intellectualization of the proposed tools through closer integration of ontological descriptions with the requirement prioritization process.

## 6. Acknowledgements

Thanks to the team of employees of the Ukrainian Scientific Center for the Development of Information Technologies, who participated in the development of theoretical foundations and relevant software tools for supporting expert activities in decision-making processes.

## References

[1] M. Sufian, Z. Khan, S. Rehman, W. Haider Butt, A systematic literature review: Software requirements prioritization techniques, in: Proceedings of the 2018 International Conference on Frontiers of Information Technology (FIT 2018), 2018, pp. 35–40. doi: 10.1109/FIT.2018.00014

[2] H. Ahuja, Sujata, G. N. Purohit, Understanding requirement prioritization techniques, in: Proceeding of the IEEE International Conference on Computing, Communication and Automation (ICCCA 2016), 2016, pp. 257-262. doi: 10.1109/CCAA.2016.7813759

[3] R. Berntsson Svensson, R. Torkar, Not all requirements prioritization criteria are equal at all times: A quantitative analysis, in: Journal of Systems and Software, 2024, 209, art. no. 111909. doi: 10.1016/j.jss.2023.111909

[4] S. Ahmad, R. Rizawanti, T. Woodings, I. Ermahani A. Jalil, MCBRank Method to Improve Software Requirements Prioritization, in: International Journal of Advanced Computer Science and Applications (IJACSA), 2022, 13(7), pp. 215-222. doi: 10.14569/IJACSA.2022.0130728

[5] H. Arshad, S. Shaheen, J.A. Khan et al., A novel hybrid requirement's prioritization approach based on critical software project factors, in: Cogn Tech Work, 2023, 25, pp. 305–324. doi: 10.1007/s10111-023-00729-3

[6] M. Sadiq, T. Hassan, S. Nazneen, AHP_GORE_PSR: Applying analytic hierarchy process in goal oriented requirements elicitation method for the prioritization of software requirements, in: Proceedings of the 2017 3rd International Conference on Computational Intelligence & Communication Technology (CICT), 2017, pp. 1-5. doi: 10.1109/CIACT.2017.7977366

[7] M. Kassab, N. Kilicay-Ergin, Applying analytical hierarchy process to system quality requirements prioritization, in: Innovations in Systems and Software Engineering, 2015, 11 (4), pp. 303-312. doi: 10.1007/s11334-015-0260-8

[8] M. Kurttila, J. Pesonen, M. Kangas, M. Kajanus, Utilizing the analytic hierarchy process (AHP) in SWOT analysis hybrid method and its application to a forest-certification case, in: Forest Policy and Economics, 2000, 1, pp. 41-52
[9] G. Popescu, C. Gasparotti, SWOT-AHP hybrid method for ranking the strategies in the shipbuilding sector, in: Journal of Business Economics and Management, 2022, 23 (3), pp. 706–730
[10] R. Ariyana, R. Amalia, D. S. Salsabilah, et al., Strategy for increasing lowland rice productivity in West Java Province with the SWOT-AHP model approach, in: Proceedings of the 3rd International Conference on Biosciences. IOP Conf. Series: Earth Work, 2023, 25, pp. 305–324. doi: 10.1007/s10111-023-00729-3
[11] O. V. Chebanyuk, O. V. Palahin, K. K. Markov, Domain engineering approach of software requirements analysis, in: Problemy prohramuvannia. 2020, 2-3, 164-172. doi: 10.15407/pp2020.02-03.164
[12] O. Nesterenko, I. Netesin, V. Polischuk, Y Selin, Multifunctional Methodology of Expert Evaluation Alternatives in Tasks of Different Information Complexity, in: Proceedings of the IEEE 3rd. International Conference on Advanced Trends in Information Theory (ATIT). 2021, pp. 226-231
[13] M. Piattini, C. Calero, F. Ruiz, Ontologies for Software Engineering and Software Technology. Springer, 2006. doi10.1007/3-540-34518-3.
[14] C. Antoniou, N. Bassiliades, A tool for requirements engineering using ontologies and boilerplates, in: Automated Software Engineering. 2024, 31 (1), 5. doi: 10.1007/s10515-023-00403-y
[15] O. Nesterenko, Y. Selin, The Teams Information Model for Software Engineering Management, in: Proceedings of 2021 IEEE 16th International Conference on Computer Sciences and Information Technologies (CSIT), 2021, 1, 341-344. doi: 10.1109/CSIT52700.2021.9648737
[16] K. Eberhard, The effects of visualization on judgment and decision-making: a systematic literature review. in: Management Review Quarterly, 2021, 73(1). doi:10.1007/s11301-021-00235-8
[17] O. Nesterenko, I. Netesin, V. Polischuk, Y Selin, Graph-based decision making for varying complexity multicriteria problems, in: Computer Science Journal of Moldova. 2022, 30(3), 391-412. doi:10.56415/csjm.v30.21
[18] F. Noviyanto, R. Razali, M.Z.A. Nazri, Understanding requirements dependency in requirements prioritization: a systematic literature review, in: International Journal of Advances in Intelligent Informatics. 2023, 9 (2), 249 – 272. doi: 10.26555/ijain.v9i2.1082
[19] R. Anwar, M.B. Bashir, A Systematic literature review of AI-based software requirements prioritization techniques, in: IEEE Access. 2023, 11, 143815–143860. doi: 10.1109/ACCESS.2023.3343252
[20] L.M. Padilla, S.H. Creem-Regehr, M. Hegarty, J.K. Stefanucci, Decision making with visualizations: a cognitive framework across disciplines, in: Cogn. Research. 2018, 3 (29), 25. doi: 10.1186/s41235-018-0120-9