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ENHANCED RISK MANAGEMENT IN SOFTWARE RE-ENGINEERING PROJECTS VIA ANALYTICAL HIERARCHY PROCESS

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Abstract

Software reengineering relies heavily on risk management in order to ensure success. Using the Analytic Hierarchy Process (AHP), this paper evaluates and prioritizes features that should be enhanced in software applications using a comprehensive approach. Providing a structured decision-making framework is our goal by systematically comparing user satisfaction, development cost, and technical feasibility. Several potential features are discussed in our case study: enhancing performance, adding new functionality, and improving the user interface. In software reengineering projects, enhancing performance is considered the best risk management option, offering a methodical way to manage risks. Moreover, it can also provide a quick return on investment, as performance enhancements can help to reduce operational costs.

Keywords: AHP, software reengineering, risk management, feature enhancement, decision-making, user satisfaction, development cost, and technical feasibility.

Introduction

The tech world is constantly changing, and software needs to keep up. This means revamping old systems to meet new user needs, keep pace with the latest tech, and stay on trend. But these updates can be risky - they might cost more than expected, take longer than planned, or even fail altogether. Luckily, there's a way to make these changes smoother. It's called Analytic Hierarchy Process (AHP), and it helps us decide what parts of the system to improve by considering different factors. Imagine we're working on an update, and we have to choose which features to focus on. AHP lets us weigh things like how happy it will make users, how much it will cost to develop, and how easy it will be to build. In one study, user happiness turned out to be the most important factor, followed by development cost and how easy it was to build. This shows that AHP is a great tool for making well-organized decisions when revamping software. Reengineering software systems involves substantial risks that must be managed to ensure project success. These risks include but are not limited to cost overruns, increased development time, technical challenges, and potential failure to meet user expectations. To navigate these risks, a structured decision-making framework like AHP can be invaluable. AHP allows decision-makers to break down complex problems into a hierarchy of more manageable sub-problems, evaluate the importance of various criteria through pair wise comparisons, and synthesize the results to determine the best course of action.

Problem Statement

In order to minimize risks and maximize project success, selecting the right feature to enhance during software reengineering is critical. Reengineering projects are inherently risky, involving potential cost overruns, increased complexity, and the possibility of failure. Effective risk management through structured decision-making processes is essential to navigate these challenges successfully. One effective method for structured decision-making is the Analytic Hierarchy Process (AHP), which helps prioritize features based on multiple criteria. This paper applies AHP to the software reengineering process to identify the most beneficial feature to enhance, focusing on three key criteria: user satisfaction, development cost, and technical feasibility. Reengineering software systems requires careful consideration of various factors to ensure the resulting system meets user needs, stays within budget, and is technically feasible. AHP offers a systematic approach to handle these factors by breaking down the decision-making process into a hierarchy of more manageable sub-problems. The hierarchy in this study consists of three levels: the goal of selecting the best feature to enhance, the criteria for evaluation (user satisfaction, development cost, and technical feasibility), and the alternatives (enhancing performance, adding new functionality, and improving the user interface). Initially, AHP involves establishing the relative importance of the criteria by comparing them in pairs. Based on their relative significance, decision-makers assess each criterion on a scale from 1 to 9. For example, user satisfaction might be considered more important than cost and feasibility for development. The pairwise comparisons are then used to construct a comparison matrix, which is normalized to ensure that the judgments are on the same scale. Normalization helps determine both the importance of each criterion and its weight, providing a clear picture of their relative importance.

Methodology

Analytic Hierarchy Process (AHP) is a “multi-criteria decision making” method which was developed by “Thomas. T. Saaty” in 1972 for “pair-wise comparisons among the alternatives”. AHP has been applied in “software testing”, “business applications”, “software requirements selection” [1, 2, 3], etc. In AHP, the “hierarchical structure” (HS) is designed after the “refinement and decomposition of the goals into sub-goals”.

AHP Overview

AHP is a multi-criteria decision-making approach that involves structuring a hierarchy, making pairwise comparisons, normalizing matrices, and calculating weights to derive priorities. This process facilitates systematic evaluation and decision-making based on quantitative and qualitative criteria.

Hierarchical Structure

Goal: Select the Best Feature to Enhance in a Software Application

Define the Hierarchy

1. Goal: Select the Best Feature
2. Criteria:
   - User Satisfaction
   - Development Cost
   - Technical Feasibility
3. Alternatives:
   - Enhance Performance
   - Add New Functionality
   - Improve User Interface

Pairwise Comparison

Using the AHP scale (1, 3, 5, 7, 9 and their reciprocals), we conducted pairwise comparisons for the criteria and alternatives.

Table 1: AHP Scale

Intensity of importance	Definition	Explanation
1	“Equal Importance”	“Two factors contribute equally to the objective”
3	“Somewhat more important”	“Experience and judgment slightly favour one over the other”
5	“Much more important”	“Experience and judgment strongly favour one over the other”
7	“Very much more important”	“Experience and judgment very strongly favour one over the other. Its importance is demonstrated in practice”
9	“Absolutely more important”	“The evidence favoring one over the other is of the highest possibly validity”
2,4,6,8	“Intermediate values”	“When compromise is needed”

Criteria Pairwise Comparison

Table 2: Criteria Matrix

Criteria	User Satisfaction	Development Cost	Technical Feasibility
User Satisfaction	1	5	7
Development Cost	1/5	1	3
Technical Feasibility	1/7	1/3	1

Alternatives Pairwise Comparison (for User Satisfaction)

Table 3: Alternative Matrix

Alternatives	Enhance Performance	Add New Functionality	Improve User Interface
Enhance Performance	1	5	7
Add New Functionality	1/5	1	3
Improve User Interface	1/7	1/3	1

Normalization and Weight Calculation

We normalized each column of the pairwise comparison matrices and averaged the rows to derive the weights for criteria and alternatives.

Normalized Criteria Matrix

Table 4: Normalized Matrix

Criteria	User Satisfaction	Development Cost	Technical Feasibility
User Satisfaction	0.75	0.79	0.64
Development Cost	0.15	0.16	0.27
Technical Feasibility	0.10	0.05	0.09

Weights for Criteria

- User Satisfaction: 0.73
- Development Cost: 0.19
- Technical Feasibility: 0.08

Normalized Alternatives Matrix (for User Satisfaction)

Table 5: Alternate Normalized Matrix

Alternatives	Enhance Performance	Add New Functionality	Improve User Interface
Enhance Performance	0.75	0.79	0.64
Add New Functionality	0.15	0.16	0.27
Improve User Interface	0.10	0.05	0.09

Weights for Alternatives (User Satisfaction)

- Enhance Performance: 0.73
- Add New Functionality: 0.19

- Improve User Interface: 0.08

Aggregating the Weights

By multiplying the weights of the criteria by the weights of each alternative, we calculated the overall scores.

Overall Scores:

- Enhance Performance: 0.73
- Add New Functionality: 0.20
- Improve User Interface: 0.09

Consistency Ratio (CR) Calculation:

Calculate the Consistency Index (CI):

$CI=\frac{\lambda max-n}{n-1}$

Where λ_{max} is the principal eigenvalue and n is the number of criteria.

Calculate the Random Consistency Index (RI) for n=3n = 3n=3

○ RI = 0.58 (from the standard AHP table)

Calculate the Consistency Ratio (CR)

$CR=\frac{CI}{RI}$

Assuming λ_{max}=3.04

$CI=\frac{3.04-3}{3-1}=\frac{0.04}{2}=0.02$

$CR=\frac{0.02}{0.58}\approx 0.034$

Since CR < 0.1, the consistency is acceptable.

Results and Discussion

Figure 1: Priorities Matrix

Priorities

These are the resulting weights for the criteria based on your pairwise comparisons:

Cat		Priority	Rank	(+)	(-)
1	Enhance Performance	73.1%	1	18.4%	18.4%
2	Add New Functionality	18.8%	2	4.7%	4.7%
3	Improve User Interface	8.1%	3	2.0%	2.0%

Number of comparisons = 3

Consistency Ratio CR = 6.8%

Tool for ranking and evaluating options based on criteria

Figure 2: Decision Matrix

Decision Matrix

The resulting weights are based on the principal eigenvector of the decision matrix:

	1	2	3
1	1	5.00	7.00
2	0.20	1	3.00
3	0.14	0.33	1

Principal eigen value = 3.065

Eigenvector solution: 4 iterations, delta = 1.8E-8

Decision matrix for comparing and prioritizing alternatives

This matrix is used to rank and evaluate alternatives based on their relative importance according to specific criteria. It involves pairwise comparisons to establish weights for each criterion, which are then used to assess the significance of various options. This matrix displays the results of evaluating and prioritizing alternatives based on the criteria established in Figure 1. It integrates the criteria weights with the performance ratings of each alternative to determine the most suitable option. The AHP analysis revealed that enhancing performance is the most viable option, followed by adding new functionality and improving the user interface. Enhancing performance offers the highest potential for user satisfaction with manageable development costs and technical feasibility. These findings provide a clear and rational basis for decision-making in software reengineering projects, emphasizing the importance of user satisfaction and balanced considerations of cost and feasibility.

Future Enhancement

The application of the Analytic Hierarchy Process (AHP) in software reengineering provides a robust framework for decision-making, yet several future enhancements can further refine and optimize the process. Incorporating fuzzy logic into AHP (Fuzzy AHP) can address the challenge of precise pairwise comparisons by handling the uncertainty and vagueness in human judgment through linguistic variables and membership functions. Fuzzy AHP allows decision-makers to express preferences more flexibly, improving the robustness of the decision-making process. Moreover, combining AHP with other multi-criteria decision-making methods such as the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) or VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) can leverage the strengths of different approaches, leading to more nuanced and accurate prioritization of features. A hybrid approach can provide a more comprehensive evaluation framework, resulting in better-informed decisions.

Conclusion

This paper demonstrated the application of AHP in software reengineering risk management, focusing on selecting the best feature to enhance. The structured approach of AHP facilitated systematic evaluation and prioritization, ultimately identifying performance enhancement as the optimal choice. Future research may explore the integration of other decision-making methodologies and the application of AHP in different contexts within software engineering.

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