Software Project Risk Assessment Model Based on Fuzzy Theory

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Abstract—**Many uncertainties always exist in the development and management process of software project, the awareness and ability of software project risk management must be strengthened, in order to effectively prevent the occurrence of the failure of it. In this paper, on the basis of the analysis of the software project risk management process, a model based on fuzzy theory in software project risk assessment is provided. Using the fuzzy language to assess the consequences and the loss of the risk, the model can measure a combination of impact of a certain risk from a variety of risk and the combined effects of the overall consequences from individual risk, which resolves the uncertainty of expert assessment, enhances the prediction and response capabilities of the software project risk and provide a new way to effectively reduce the risk probability and increase the rate of the success of the software development.**

Keywords-software project; risk management; risk assessment; fuzzy theory

I INTRODUCTION

Software project risk is about the cost, schedule and functional problems encountered in the process of software development and how they impact on the software project[1]. The software project risk assessment is to identify risk factors that can lead to the lack of clarity of project requirements, the delivery not according to schedule and time, product quality deficiencies, excessive expenditures and other adverse consequences and qualitative and quantitative analyze the risk factors and possible effects and hazards, so as to provide an effective risk control programs and measurements to software project management personnel, software developers, software product users, etc and to reduce the loss and impact to a minimum. Thus, in a sense, the software project management is software project risk management to a large extent.

II SOFTWARE PROJECT RISK MANAGEMENT PROCESS

The development of software projects exists various risks and some risks are even disastrous. Risk management is a kind of activity that can identify risks and develop risk plans, minimizing the impact of risk on projects. Software project risk management is intended for identifying, treating and eliminating the source of the risks before the threat of risks that may lead to the failure of the projects. Software project risk management process is made up of risk assessment and risk control. Risk assessment involves risk identification, risk analysis and risk plans and risk control is divided into risk tracking and risk response. Software project risk management process is shown in Figure 1.

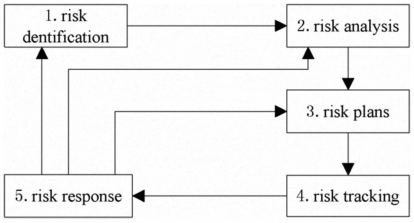

Figure 1 Software project risk management process

Risk assessment is the core and foundation of software project risk management, directly affecting other processes and even the success or failure of the software projects.

III FUZZY THEORY AND ITS APPLICATIONS

A. *The definition of fuzzy set and its representation*

The fuzzy logic built on the fuzzy promotion of the binary logic is close to people's way of imaginal thinking, which is very suitable for qualitative analysis and reasoning, and at the same time, it has a strong ability to deal with natural language. Zadeh introduced the concept of fuzzy sets in order to quantitatively describe fuzzy concepts and fuzzy phenomenon[2]. the representation of fuzzy sets is as follows:

$$A=\sum_{i=1}^{n}\mu(\chi_i)/\chi_i \qquad (1)$$

The finite set $X=\{\chi_1,\chi_2,\ldots,\chi_n\}$, $\mu(\chi_i)$ is called the grade of membership of χ_i in (A, μ). If $\mu(\chi_i)=0$, you don't need to write it.

The form of fuzzy numbers is plenty, and the most commonly used is the triangular fuzzy numbers. Triangular fuzzy numbers A$\in$ [0,1] can be represented as follows:

$$A=(l, m, n) \qquad (2)$$

Among them, 1 is called the most pessimistic value, m is the most possible value and n is called the most optimistic value. Membership function $\mu(m)=1$.

B. *Semantic distance and semantic reduction*

Since the result calculated by the fuzzy theory is fuzzy, It is necessary to restore the natural language expressions in order to cater to people's habit of thinking. This is what we call semantic similarity or semantic reduction. To achieve this aim, need to find and book the closest fuzzy terms among the fuzzy sets. Set A, B is separately the fuzzy set in the domain of X corresponding fuzzy concept, i means the value of α, n is the number of α - cut set, then there is Euclidean distance:

$$d(A,B)=\sqrt{\sum_{i}^{n}\left[\{A_{\min}(i)-B_{\min}(i)\}^2+\{A_{\max}(i)-B_{\max}(i)\}^2\right]} \qquad (3)$$

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Calculating the distance between fuzzy numbers and default fuzzy language, the least one shall be the closest natural language[3].

C. The application of fuzzy theory

The applications of fuzzy theory in the software project risk assessment mainly show in the following three aspects:

(1) Risk consequence assessment. First, after the recognition of software project risks, using fuzzy reviews the consequences of the definition of risk on the set of fuzzy reviews, then the set will be involved in calculations as the form of fuzzy numbers[4].

(2) Risk impact calculation. Combined with the risk probability calculated from risk analysis network, calculate risk equivalent, the impact of portfolio risks and integrated risks.

(3) Assessment consequences reduction. In order to make risk assessment more intuitive, the final multi-dimensional assessment consequence needs to restore to the natural language presentation and to restore to the semanteme by calculating the distance between the result of the assessment and the established fuzzy comments.

IV SOFTWARE PROJECT RISK ASSESSMENT MODEL

A. Model design

Software project risk assessment model is based on fuzzy theory, then the domain experts will use fuzzy language to evaluate and calculate the probability and impact of risks by the calculation of fuzzy cut sets, and then to calculate the combined effects of risk and sort them after defuzzification, and finally use the semantic distance between fuzzy numbers to restore assessment results into a natural language description[5]. The software project risk assessment model is shown in Figure 2.

B. Risk probability assessment

Risk assessment process is carried out based on risk factor nodes. Risk analysis network is an acyclic graph indicated the probability dependence between variables, each node corresponds to a conditional probability distribution table (CPT), clearly explaining the quantitative relationship of probability dependence between this variable and its parent node[6].The steps of the risk probability assessment are:

(1) Define fuzzy reviews set of the risk probability. In the absence of historical data, domain experts will use the "impossible", "may" and other fuzzy language to evaluate risk probability, that is, fuzzy reviews set H_p={highly impossible, impossible, moderate, maybe, possible};

(2) Risk probability assessment is the use of fuzzy reviews set H_p, setting the conditional probability and prior probability in the risk analysis network and forming a conditional probability distribution table.

(3) Theorize the probability of the risk based on risk analysis network structure and conditional probability distribution table, and then calculate the probability comprehensive assessment matrix $P_{composite}$= $[P_1,P_2\ldots,P_n]$ of each node;

(4) In the process of assessment, with the acquisition of new information (evidence), it has real-time transmission of the network and update.

C. Risk impact assessment

Risk impact assessment includes two parts, the assessment of the loss of risk and the comprehensive assessment of risk impact. The steps of the risk impact assessment are:

(1) Define risk factors consequence set D= $\{D_1, D_2\ldots, D_n\}$, consequences of risk on fuzzy reviews set H_c={very low, low, medium, high, very high}.

(2) Risk loss assessment. The experts will use fuzzy reviews set H_c to construct fuzzy expert assessment matrix C, evaluating various risks' impact on set D.

(3) The calculation of risk weights. Using the weight coefficient vector of risk factors $A=[a_1, a_2,\ldots, a_n]^T$ to represent, n means the number of risk factors, a_i means the relative importance of i-class risk factors.

(4) Comprehensive assessment of risks. Risk equivalent is a key indicator of the level of risk. The current method is usually to measure the hazard level of a single risk on various risk consequences from the product of risk probability and consequences.

V VALIDATION

In the analysis of system and the part of design, there always exists some factors such as imperfect project plan, uncertain demand, inappropriate technology or method, and these factors largely influence each other, which is particularly important for risk assessment. This article will take the example of manufacturing information public service platform project to illustrate how to utilize fuzzy theory to carry out risk assessment in the software projects.

A. Problem description

Manufacturing information public service platform belongs to innovative projects; as a result, project team needs to change in the development process more frequently, and it is difficult for developers to control the development platform and development technologies, which has a greater impact on the improvement of software performance.

Implementing the risk assessment when the project starts, firstly, we need identify the risk and risk factors in the project and set the key words of risks, that is demand risk, demand changes, technology risk, personnel communication and software performance security strategies, etc. Based on existing cases to start the risk cases learning mechanism and combined with experts' experience, the network of risk assessment is shown as Figure 3.

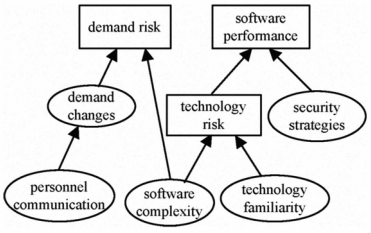

Figure 3 risk analysis network

B. Risk Assessment

Based on the topology of risk analysis network and the knowledge of experts in the field, the conditional probability of each network node is set following the steps

in risk assessment of probability. The CPT settings of software performance risk node in the Figure 3 shows in Table 1.

Table 1 software performance risk node CPT settings

Technology risk	Security strategies	Software performance=true
0	0	0.02
0	1	0.3
1	0	0.45
1	1	0.9

Based on the characteristics of application system, experts define the risk consequences set D= {progress, costs, software quality}, use the comments on the manufacturing information public service platform to assess the loss of risk, call the risk-equivalent formula R=P*C based on risk assessment loss and the probability of occurrence of risk nodes and finally get accurate data on the risk-equivalent as shown in Table 2.

Table 2 Quantitative data of risk-equivalent

risk\lost\ consequence	progress	costs	Software quality
Demand risk	0.47	0.24	0.03
Technology risk	0.54	0.36	0.78
Software performance	0.25	0.25	0.67

This article takes indirect method to calculate the semantic distance between fuzzy numbers. Define fuzzy numbers A and B, in which A is triangular fuzzy number and B is scheduled fuzzy reviews. The fuzzy number of A and B respectively express as (l_1, m_1, n_1) and (l_2, m_2, n_2).According to formula (3), the distance between two fuzzy numbers A and B is:

$$d(A,B)=\sqrt{(l_1-l_2)^2+2(m_1-m_2)^2+(n_1-n_2)^2} \quad (4)$$

By computing, the semantic reduction is as shown in Table 3.

Table 3 risk semantic reduction

consequences\ loss\risk	Demand risk	Technology risk	Software performance
Progress	high	high	Medium
Costs	Medium	Medium	Medium
quality	low	Extremely high	Extremely high

VI CONCLUSIONS

Based on the fuzzy theory, the paper comes up with a new model of software project risk assessment, overcoming the difficulty of qualitative indicators and quantitative assessment in the traditional analysis methods. Practice shows that using fuzzy language to assess the loss of risk and adopting fuzzy logic process technology to calculate can help to solve the problems of uncertainty in the expert assessment. The semantic distance calculation of fuzzy numbers and the reduction of assessment results provide a basis for classification of all types of risk, largely avoiding and reducing the loss. Example proves that the method is highly scientific and effective, which can be well applied into software project risk assessment.

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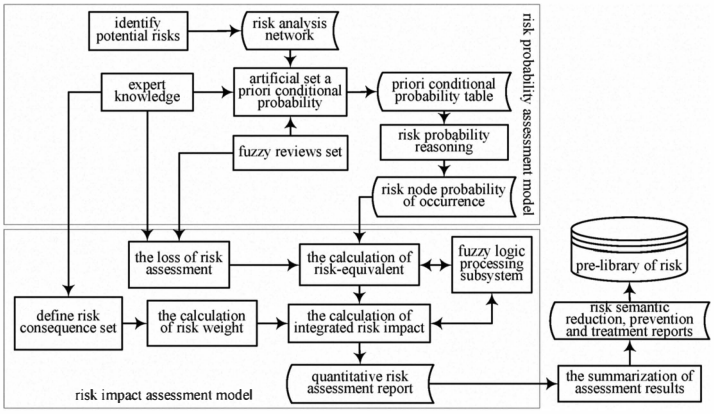

Figure 2 software project risk assessment model